

**Attachment 1**

**PM-2A Tanks — Specifications**

**Attachment 2**  
**TSF-03 — Specifications**

**Attachment 3**

**WRRTF-01 — Specifications**

## REFERENCE PAGES

# INEEL BBWI RFP-394 RD/RA Work Plan for WAG 1-10 ==> Crane Lifting / Loading Calculations

WAG 1-10 Sites TSF-26, TSF-03, and WRTTF-01



INTREPID prepared Revision 0 dated - 13-Jan-2003, by DJ Kenoyer, Checked by SD Dustin

1 Revision 1, 24-Feb-03, by DJ Kenoyer

2 Revision 2, 15-Jul-03, by DJ Kenoyer

3 100% Rev 1, 28-Jul-03, by DJ Kenoyer / Changed Tank Thickness to be MORE Conservative to 1/4" from 3/16"

4 Draft FINAL, 29-Sep-03 by DJ Kenoyer / Changed Tank Thickness from 1/4" to the 1/2" found during September 2003 Tank Sampling efforts by BBWI

5 07-Nov-03 by DJ Kenoyer / Tank Exterior Tar Coating Thickness from 1/2" to 1" found during September 2003 Tank Sampling efforts by BBWI

6 20-Nov-03 by DJ Kenoyer / Tank Exterior Tar Coating Thickness 1/16" confirmed by BBWI ==> NOT 1/2" to 1" as reported earlier

7 01-Dec-03 by DJ Kenoyer / Tank Steel thickness 5/8" confirmed by BBWI ==> NOT 1/2" as reported earlier [Revision 4]

## Original Configuration

Description	diameter (lineal feet)	length	depth	Area (square feet)	Thickness (inches)	Unit (lbs/sf)	Weight		Total (lbs)	Half-PM2A (lbs)
							Tank (lbs)	Added (lbs)		
Weight Calculations										
7					5/8	25.60	61,575	4,310	65,885	32,943 7
7	Specific Weight of "TAR"	72 lbs per cubic foot			0.06	0.38	902	63	965	483 6
										33,425 7 & 6
	Specific Weight of "TAR"	72 lbs per cubic foot			1/2	20.40	49,068	3,435	52,502	26,251 4
					0.06	0.38	902	63	965	483 6
										26,734 4 & 6
PM2A Tank	12.5	55.0		2,405.3	3/8	15.30	36,801	2,576	39,377	19,688
					5/16	12.80	30,788	2,155	32,943	16,471
Assume Tank Ribs and Manways ==>	7.0%	Added Weight			1/4	10.20	24,534	1,717	26,251	13,126 3
					3/16	7.65	18,400	1,288	19,688	9,844
					1/8	5.10	12,267	859	13,126	6,563

Description	width (lineal feet)	length (lineal feet)	height (lineal feet)	Length (lineal feet)	Width (lineal feet)	Unit (lbs/sf)	Weight		Total (lbs)
							THA (lbs)	Added (lbs)	
2 Weight Calculations for RUBB THA Shelter									
THA 8 Meter	26.2	65.0		40.0	26.2		5,050		5,050
				25.0		71.00		1,775	1,775
								5.0%	350
									7,175
2 Weight Calculations for RUBB Special Shelter									
THA 22'0" Walls	16.0	35.0		35.0	16.0	8.0	4,480		4,500
								5.0%	230
									4,730

Description	width (lineal feet)	length (lineal feet)	thickness (lineal feet)	Volume (cubic feet)	Unit (lbs/cf)	Weight		Total (lbs)
						Precast (lbs)	Added (lbs)	
2 Weight Calculations for Precast "C" Section Shielding Concrete								
Sides	2	6.0	9.8	87.8	145.0	12,724		12,724
End	1	6.0	13.8	62.2	145.0	9,024		9,024
Percentage Contingency for Added Steel Reinforcing ==>							4.5%	980
								22,728

## Technical Specifications for Grove Mobile Hydraulic Crane GMK5240 [240 ton crane]

Whole Tank	Half Tank
52,502	26,251
	26,734 4 & 6
(lbs)	(lbs)
Percent Lift Capacity	

(b-lineal feet)	(h-lineal feet)	(degrees)	(lbs)		
105.0	80.0	40.4	53,000	99.1%	49.5%
121.0	100.0	34.3	36,000	145.8%	72.9%
136.0	110.0	36.0	32,200		
151.0	120.0	37.4	24,800		

Distance from C/L Crane to C/L of Load ==> (h-lineal feet)

		Horizontal Distance - Crane to Tank		Lift Capacity	Percent Loading
Grove 5240 Counterweights	154,300 pounds	V-13	East Tank 80.0 h-lineal feet	53,000	49.5% 4
Outrigger Status - Extensions	100% 273" Spread	V-14	West Tank 100.0 h-lineal feet	36,000	72.9% 4
Crane Rotation Status	360 degrees	RUBB THA	26.2' x 65.0 110.0 h-lineal feet	7,175	32,200 22.3% 4
		Precast "C" Shape	110.0 h-lineal feet	22,728	32,200 70.6%

Long High Capacity Trailers Available ==> 2003 Fontaine Specialized TDFT Telescopic Step, Drop Decl Extendable

102" wide / 48'-69' deck / 80,000 lbs capacity

		Horizontal Distance - Crane to Tank		Lift Capacity	Percent Loading
V-13	East Tank	80.0	h-lineal feet	53,000	50.4% 4 & 6
V-14	West Tank	100.0	h-lineal feet	36,000	74.3% 4 & 6
RUBB THA	26.2' x 65.0	110.0	h-lineal feet	7,175	32,200 22.3%
Precast "C" Shape		110.0	h-lineal feet	22,728	32,200 70.6%

		Horizontal Distance - Crane to Tank		Lift Capacity	Percent Loading
V-13	East Tank	80.0	h-lineal feet	53,000	63.1% 7 & 6
V-14	West Tank	100.0	h-lineal feet	36,000	92.8% 7 & 6
RUBB THA	26.2' x 65.0	110.0	h-lineal feet	7,175	32,200 22.3%
Precast "C" Shape		110.0	h-lineal feet	22,728	32,200 70.6%

It was noted that Eq 15 is the equation of a circle with axes  $\sigma$  and  $\tau$  and centered on the  $\sigma$  axis with:

$$\text{center} = \left( \frac{\sigma_x + \sigma_y}{2} \right) \quad (\text{Eq 16})$$

and radius,  $R$ , given by:

$$R^2 = \left( \frac{\sigma_x + \sigma_y}{2} \right)^2 + \tau_{xy}^2 \quad (\text{Eq 17})$$

The result is that stress transformations can be performed by using the geometric principles of a circle. For example, if stresses are known at a point, they are plotted on a figure that has horizontal axis  $\sigma$  and vertical axis  $\tau$  so that  $(\sigma_x, \tau_{xy})$  is the coordinate point at horizontal position  $\sigma_x$  and vertical position  $\tau_{xy}$  and so that  $(\sigma_y, \tau_{xy})$  is the coordinate that corresponds to  $\sigma_y$  and  $\tau_{xy}$ . Since the center of the circle is on the  $\sigma$  axis, this can be easily found by Eq 16. The radius of the circle is given by Eq 17. From this, the entire circle can be drawn. This is illustrated by the schematic Mohr's circle in Fig. 5.

Then for a rotation of axes by  $\theta$  in the stress element, the position on the Mohr's circle must go through a rotation of  $2\theta$  in the same direction but around the circumference of the circle. Every point on the circle corresponds to a possible stress pair. Note that a rotation of  $180^\circ$  of the circle corresponds to a rotation of the stress element by  $90^\circ$  so that  $\sigma_x$  is transformed to  $\sigma_y$  as shown in Fig. 5.

**Principal Stresses.** The purpose of a stress transformation is mainly to find the stresses that can be used in a failure criterion. These would be either the largest magnitude stresses in any direction or the magnitude of stresses on a weak plane. For the former, the extreme stresses can be found by taking Eq 11 and applying the calculus principle  $d\sigma_x/d\theta = 0$ . That is, principal stresses are normal (perpendicular) stresses on planes for which the shear stresses are zero. The values of principal stresses are given by:

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left( \frac{\sigma_x - \sigma_y}{2} \right)^2 + \tau_{xy}^2} \quad (\text{Eq 18})$$

where the positive radical gives a maximum stress labeled  $\sigma_1$  and the negative radical a minimum stress  $\sigma_2$ . Notice that the positions of the extreme stresses are the points on the Mohr's circle where the circle crosses the  $\sigma$  axis (horizontal axis) (Fig. 5).

The right side of the circle corresponds to a maximum normal stress and the left side to a minimum stress. These stresses are called principal stresses and are often labeled  $\sigma_1$  and  $\sigma_2$ . Notice that the extremal stress given by Eq 18 is equivalent to taking the center  $\pm$  the radius of the Mohr's circle. In this way the extreme values of stresses can be easily found by simply using the Mohr's circle.

The maximum shear stress,  $\tau_{\max}$ , can also be found by taking  $\tau_{x'y'}$  from Eq 12 and using the calculus principle  $d\tau_{x'y'}/d\theta = 0$ . This results in:

$$\tau_{\max} = \pm \sqrt{\left( \frac{\sigma_x - \sigma_y}{2} \right)^2 + \tau_{xy}^2} \quad (\text{Eq 19})$$

The value of  $\tau_{\max}$  is the radius of the Mohr's circle, and the corresponding points on the Mohr's circle are at the top and bottom of the circle as shown in Fig. 5. The maximum shear stress could also be written as:

$$\tau_{\max} = \frac{\sigma_1 - \sigma_2}{2} \quad (\text{Eq 20})$$

Note that the maximum normal stresses are defined at a position where the shear stresses are zero. A plane with zero shear stress is defined as a principal stress plane, that is, a plane having only normal stresses. This can be extended to three dimensions. Given a symmetric stress tensor as defined previously, a transformation is desired to a plane that results in the stress tensor having only normal stress components; all shear components are zero. This would be given by:

$$\begin{pmatrix} \sigma_1 & 0 & 0 \\ 0 & \sigma_2 & 0 \\ 0 & 0 & \sigma_3 \end{pmatrix}$$

The transformation results in a cubic equation in  $\sigma$  given by:

$$\sigma^3 - I_1\sigma^2 + I_2\sigma - I_3 = 0 \quad (\text{Eq 21})$$

where

$$\begin{aligned} I_1 &= \sigma_x + \sigma_y + \sigma_z \\ I_2 &= \sigma_x\sigma_y + \sigma_y\sigma_z + \sigma_z\sigma_x - \tau_{xy}^2 - \tau_{yz}^2 - \tau_{zx}^2 \\ I_3 &= \sigma_x\sigma_y\sigma_z + 2\tau_{xy}\tau_{yz}\tau_{zx} - \sigma_x\tau_{yz}^2 \\ &\quad - \sigma_y\tau_{zx}^2 - \sigma_z\tau_{xy}^2 \end{aligned} \quad (\text{Eq 22})$$

The values of the coefficients,  $I_1$ ,  $I_2$ , and  $I_3$  are called the stress invariants and are independent of the coordinate system used to describe the stress state. However, here they are used to solve the stress cubic given in Eq 21 so that three principal stresses result:  $\sigma_1$ ,  $\sigma_2$ , and  $\sigma_3$ . In three dimensions, the maximum shear stresses can be found in the same way to the 2D stresses, that is as one-half the difference of any two principal stresses.

If stresses  $\sigma_1$ ,  $\sigma_2$ , and  $\sigma_3$  are ordered from maximum to minimum, then the absolute maximum shear stress in three dimensions is:

$$\tau_{\max(\text{abs})} = \frac{\sigma_1 - \sigma_3}{2} \quad (\text{Eq 23})$$

The transformation of stress in three dimensions can be made with equations like Eq 14. For this transformation, a circle like the Mohr's circle

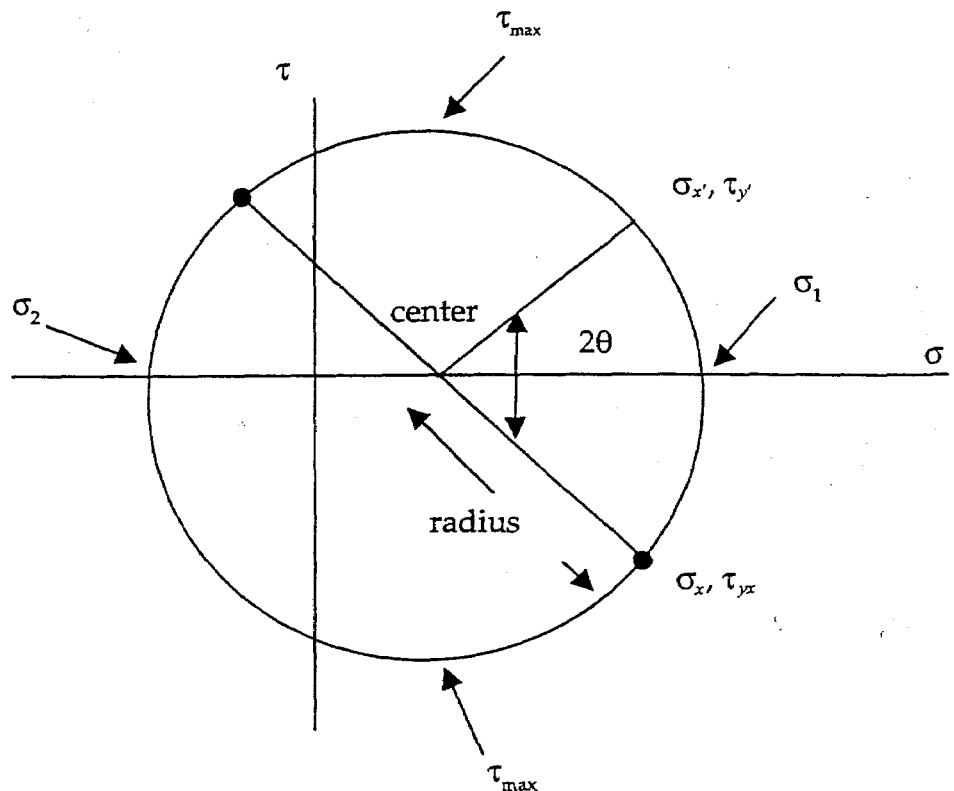


Fig. 5 Mohr's circle for two-dimensional stress transformation

## Cubic Equation Calculator

Input **MUST** have the format:  $AX^3 + BX^2 + CX + D = 0$

**EXAMPLE:** If you have the equation:  $2X^3 - 4X^2 - 22X + 24 = 0$

then you would input: A= 2 B= -4 C= -22 D=24

Click **E N T E R** and your answers should be 4, -3 and 1

A=  B=  C=  D=

**E N T E R**

$X_1 =$

$X_2 =$

$X_3 =$

To see the method for solving cubic equations, click [HERE](#)

Copyright © 2000 1728 Software Systems

## 8. COMBINED STRESS

Under certain circumstances of loading a body is subjected to a combination of tensile, compressive, and/or shear stresses. For example, a shaft which is simultaneously bent and twisted is subjected to combined stresses, namely, longitudinal tension and compression and torsional shear. For the purposes of analysis it is convenient to reduce such systems of combined stresses to a basic system of stress coordinates known as principal stresses. These stresses act on axes which differ in general from the axes along which the applied stresses are acting and represent the maximum and minimum values of the normal stresses for the particular point considered.

**Determination of Principal Stresses.** The expressions for the principal stresses in terms of the stresses along the  $x$  and  $y$  axes are

$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \quad (1)$$

$$\sigma_2 = \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \quad (2)$$

$$\tau_1 = \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \quad (3)$$

where  $\sigma_1$ ,  $\sigma_2$ , and  $\tau_1$  are the principal stress components and  $\sigma_x$ ,  $\sigma_y$ , and  $\tau_{xy}$  the calculated stress components, all of which are determined at any particular point (Fig. 1).

**Graphical Method of Principal Stress Determination—Mohr's Circle.** Let the axes  $x$  and  $y$  be chosen to represent the directions of the applied normal and shearing stresses, respectively (Fig. 2). Lay off to suitable scale distances  $OA = \sigma_y$ ,  $OB = \sigma_x$ , and  $BC = AD = \tau_{xy}$ . With point  $E$  as a center construct the circle  $DFC$ . Then  $OF$  and  $OG$  are the principal stresses  $\sigma_1$  and  $\sigma_2$  respectively, and  $EC$  the maximum shear stress  $\tau_1$ . The inverse

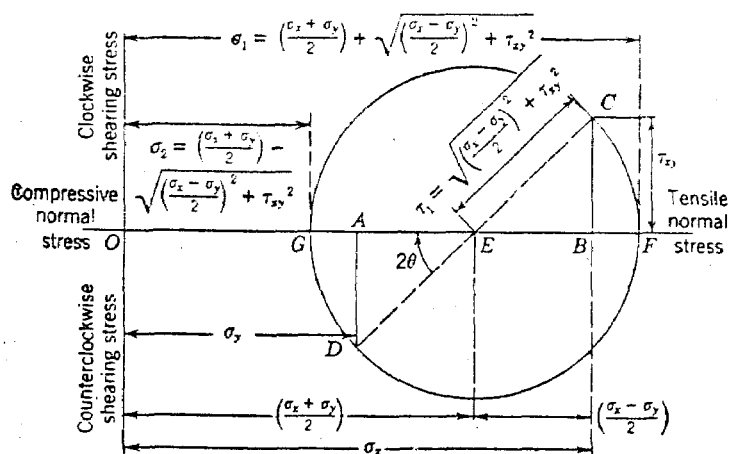


FIG. 2. Mohr's circle used for the determination of the principal stresses. (Reproduced with modification by permission from Joseph Marin, *op. cit.*)

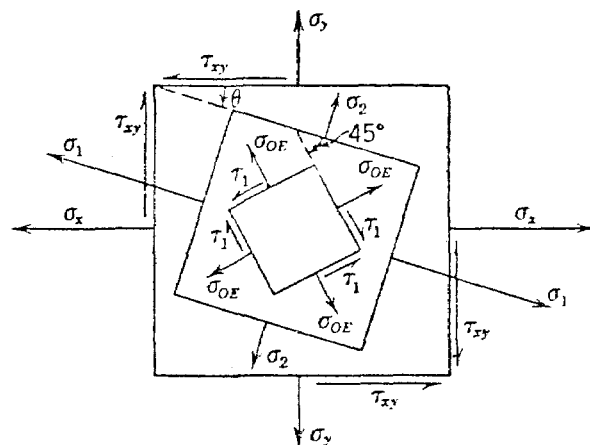


FIG. 1. Diagram showing relative orientation of stresses. (Reproduced with modification by permission from *Mechanical Properties of Materials and Design*, by Joseph Marin, McGraw-Hill Book Co.)

also holds; that is, given the principal stresses,  $\sigma_x$  and  $\sigma_y$  can be determined on any plane passing through the point.

**Stress-strain Relations.** The linear relation between components of stress and strain is known as *Hooke's law*. This relation for the two-dimensional case can be expressed as

$$\epsilon_x = \frac{1}{E} (\sigma_x - \nu \sigma_y) \quad (4)$$

$$\epsilon_y = \frac{1}{E} (\sigma_y - \nu \sigma_x) \quad (5)$$

$$\gamma_{xy} = \frac{1}{G} \tau_{xy} \quad (6)$$

where  $\sigma_x$ ,  $\sigma_y$ , and  $\tau_{xy}$  are the stress components of a particular point,  $\nu$  = Poisson's ratio,  $E$  = modulus of elasticity,  $G$  = modulus of rigidity, and  $\epsilon_x$ ,  $\epsilon_y$ , and  $\gamma_{xy}$  = strain components.



# CONSOLIDATED

RIGGING & MARINE SUPPLY CO. INC.

PO BOX 3235

4700 N. PEARL STREET

JACKSONVILLE FL. 32206

PHONE 904-765-7177

FAX 904-765-2056

TOLL FREE 800-445-8965

## FAX TRANSMISSION

### COVER SHEET

PAGE 1 OF 2

FROM THE DESK OF MIKE COKER

ATTN: Lowell magleby

COMPANY: \_\_\_\_\_

DATE: 12-15-03

Example

PM-2A Application

1 1/8" Wire Rope

\$432.60 EACH

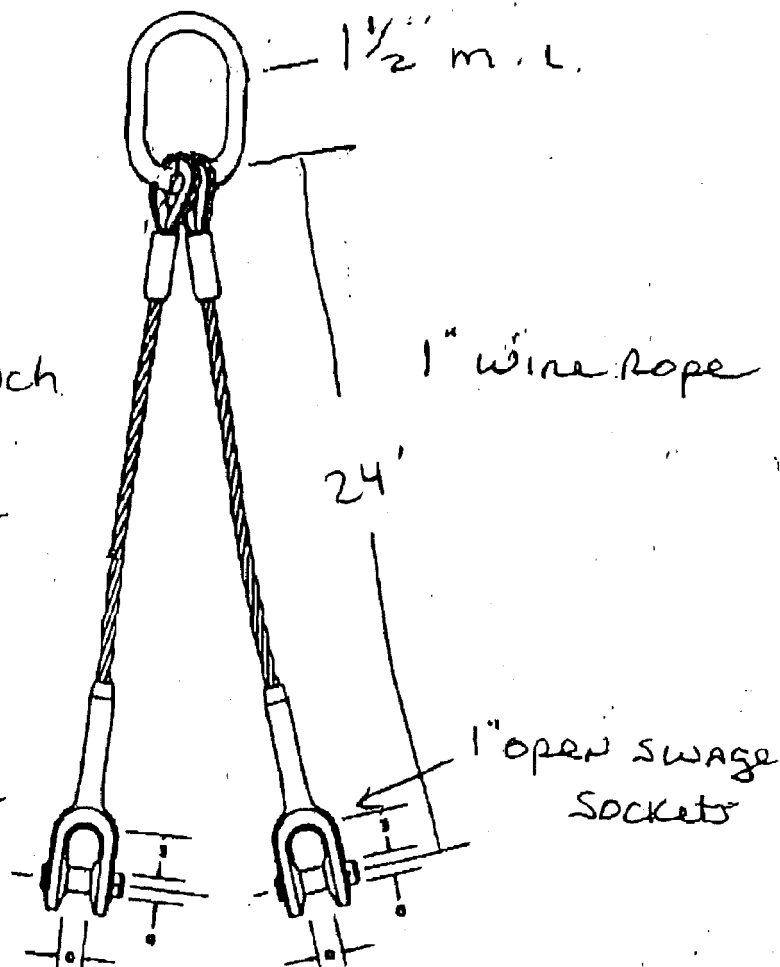
Add \$40.00 for

Testing + Tag

FOB: JAX FL

COD, Credit + Card

Mike Coker



## Consolidated Rigging & Marine Supply

Cable  
Cordage  
Chain  
Cargo Nets  
Slings

4700 N. Pearl Street  
Jacksonville, Florida 32206

(800) 445-8965 (toll-free) - (904) 765-2056 (fax)



*Click on item  
to change*

**Specialists in Rigging, Slings, Cable, Chain and Lifting Products...**

**For a Full 85 Page Catalog, please contact us.**

[home page](#)

[about us](#)

[line card](#)

[catalog](#)

[contact us](#)

[safety class](#)

[related links](#)

**PAGE 1 – Slings with Chokers, Baskets, 2-legged/4-legged Spreaders**

**PAGE 2 – No. 105-A Sling with Single-Rope Legs and Torpedo Loop-Locks**

**PAGE 3 – Slings with Single-Rope Legs and Open/Closed Swaged Sockets**

**PAGE 4 – Chain Slings - Single, Double, Triple, Quad and Standard**

**PAGE 5 – Wire Rope**

**PAGE 6 – Galv. and Stainless Wire Rope**

**PAGE 7 – Endless Round Sling**

**PAGE 8 – Nylon Web Products - Eye, Eye Slings and Endless Slings**

**PAGE 9 – Important Features to look for in a Quality Sling...**

**[ [home page](#) ] [ [about us](#) ] [ [line card](#) ] [ [catalog](#) ] [ [contact us](#) ] [ [related links](#) ] [ [Te](#)**

4700 N. Pearl Street, Jacksonville, Florida 32206 | (800) 445-8965 (tollfree) | (904) 765-2056 (fax)

Copyright 2002 Consolidated Rigging & Marine Supply | [location map](#) | [city map](#) | [webmaster](#)

# Consolidated Rigging & Marine Supply

Cable  
Cordage  
Chain  
Cargo Nets  
Slings

4700 N. Pearl Street  
Jacksonville, Florida 32206







(800) 445-8965 (toll-free) - (904) 765-2056 (fax)



## Slings with Chokers, Baskets, 2-legged/4-legged Spreaders...

< Previous

Print Page

	SIZE	6 x 19 or 6 x 37 IWRC									
			6 x 12 IWRC	6 x 18 IWRC	6 x 18 IWRC	15'	30'	45'	15'		30'
50	1/4"	56	56	42	1.1	1.1	97	79	2.1	1.9	1
75	5/16"	87	87	65	1.7	1.7	1.5	1.2	3.4	3.0	2
1	3/8"	1.2	1.2	.93	2.5	2.4	2.1	1.8	4.8	4.3	3
1.5	7/16"	1.7	1.7	1.3	3.4	3.3	2.9	2.4	6.5	5.8	4
2	1/2"	2.2	2.2	1.6	4.4	4.2	3.8	3.1	8.4	7.6	6
2.63	9/16"	2.7	2.7	2.1	5.5	5.3	4.8	3.9	11	9.5	7
3.25	5/8"	3.4	3.4	2.5	6.8	6.6	5.9	4.8	13	12	9
4.75	3/4"	4.9	4.9	3.6	9.7	9.4	8.4	6.9	19	17	11
6.5	7/8"	6.6	6.6	4.9	13	13	11	9.3	25	23	13
8.5	1"	8.5	8.5	6.4	17	16	15	12	33	29	15
9.5	1-1/8"	10	10	7.8	21	20	18	15	40	36	17
12	1-1/4"	13	13	9.6	26	25	22	18	50	44	19
13.5	1-3/8"	15	15	11	31	30	27	22	60	53	21
17	1-1/2"	18	18	14	36	35	32	26	71	63	23
21	1-5/8"	21	21	16	42	41	37	30	82	74	25
25	1-3/4"	25	25	18	49	47	43	35	95	85	27
	1-7/8"	28	28	21	56	54	49	40	109	97	29
35	2"	32	32	24	64	61	55	45	123	110	31
	2-1/4"	38	38	28	75	73	66	54	147	132	33
50	2-1/2"	46	46	34	92	89	80	65	178	159	35

Tons

shackle

Two Port  
Sling

Print Page

4700 N. Pearl Street, Jacksonville, Florida 32206 | (800) 445-8965 (tollfree) | (904) 765-2056 (fax)

Copyright 2002 Consolidated Rigging & Marine Supply | [location map](#) | [city map](#)

# Consolidated Rigging & Marine Supply

Cable  
Cordage  
Chain  
Cargo Nets  
Slings

4700 N. Pearl Street  
Jacksonville, Florida 32206

(800) 445-8965 (toll-free) - (904) 765-2056 (fax)



## Nylon Web Products - Eye, Eye Slings and Endless Slings...

< Previous

Print Page

### CONSOLIDATED RIGGING

NYLON WEB PRODUCTS  
MFG IN OUR SAVANNA GA. PLANT

TYP

TYP 4

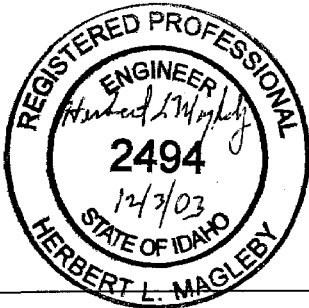
TYPE

#### EYE EYE (FLAT OR TWISTED EYE)

#### ENDLESS SLINGS (MOST VERSATILE WFR SL)

	Code	Rated Capacities in Lbs.		
		Vertical	Choker	V. Basket
One Ply	EE1-801	1,600	1,250	3,200
	EE1-802	3,200	2,500	6,400
	EE1-803	4,800	3,800	9,600
	EE1-804	6,400	5,000	12,800
	EE1-805	8,000	6,400	16,000
	EE1-806	9,600	7,700	19,200
	EE1-808	12,800	10,200	25,600
	EE1-810	16,000	12,800	32,000
Two Ply	EE1-812	19,200	15,400	38,400
	EE2-801	3,200	2,500	6,400
	EE2-802	6,400	5,000	12,800
	EE2-803	8,600	6,900	17,200
	EE2-804	11,500	9,200	23,000
	EE2-805	13,600	10,900	27,200
	EE2-806	16,300	13,000	32,600
	EE2-808	19,200	15,400	38,400
Three Ply	EE2-810	22,400	17,900	44,800
	EE2-812	26,900	21,500	53,800
	EE3-801	4,100	3,300	8,200
	EE3-802	8,300	6,600	16,600
	EE3-803	12,500	10,000	25,000
	EE3-804	16,000	12,800	32,000
	EE3-805	19,200	15,400	38,400
	EE3-806	23,000	18,400	46,000
Four Ply	EE3-808	30,700	24,500	61,400
	EE3-810	36,800	29,400	73,600
	EE3-812	44,000	35,200	88,000
	EE4-801	5,000	4,000	10,000
	EE4-802	10,000	8,000	20,000
	EE4-803	14,900	11,900	29,800
	EE4-804	19,800	15,800	39,600
	EE4-805	24,800	19,800	49,600
	EE4-806	29,800	23,800	59,600
	EE4-808	39,700	31,700	79,400
	EE4-810	49,600	39,600	99,200
	EE4-812	59,500	47,600	119,000
	EN1-801	3,200	2,500	6,400
	EN1-802	6,400	5,000	12,800
	EN1-803	8,600	6,900	17,200
	EN1-804	11,500	9,200	23,000
	EN1-805	13,600	10,900	27,200
	EN1-806	16,300	13,000	32,600
	EN1-808	19,200	15,400	38,400
	EN1-810	22,400	17,900	44,800
	EN1-812	26,900	21,500	53,800
	EN2-801	6,200	4,900	12,800
	EN2-802	12,200	9,800	24,000
	EN2-803	16,300	13,000	32,600
	EN2-804	20,700	16,500	41,400
	EN2-805	24,500	19,600	49,600
	EN2-806	28,600	23,000	57,600
	EN2-808	30,700	24,500	61,400
	EN2-810	33,600	26,800	67,200
	EN2-812	37,600	30,000	75,200
	EN3-801	8,000	6,400	16,000
	EN3-802	16,000	12,800	32,000
	EN3-803	21,500	17,200	42,000
	EN3-804	26,700	21,000	51,400
	EN3-805	34,000	27,200	65,600
	EN3-806	40,700	32,500	79,400
	EN3-808	46,000	36,800	89,600
	EN3-810	51,500	41,200	100,000
	EN3-812	59,200	47,300	116,000
	EN4-801	10,000	8,000	20,000
	EN4-802	19,800	15,800	39,600
	EN4-803	28,700	21,300	57,200
	EN4-804	35,600	28,400	71,600
	EN4-805	42,200	33,700	84,000
	EN4-806	50,500	40,400	101,000
	EN4-808	57,600	46,000	114,000
	EN4-810	67,200	53,700	134,000
	EN4-812	80,700	64,500	161,000

strap →

<b>EDF Title: TSF-26 PM2A HALF-TANK LIFTING LUGS DESIGN</b>				
Project No.: 2000-096			Project Title: OU 1-10, TSF-26 REMEDIATION	
Project Specific Activity: PM2A HALF TANK LIFTING LUGS DESIGN AND CALCULATIONS				
<b><u>Problem Statement:</u></b>				
<p>Design lifting lugs with tank reinforcing pads that can be welded to the PM-2A top and bottom half tanks and used to attach the rigging to lift the half tanks.</p>				
<b><u>Summary of Conclusions:</u></b>				
<p>The design chosen is to weld ½ inch steel plates 2 ft long and 1 ft high to the outer surface of the tank at the locations of the reinforcement ribs where the rigging is to be attached and to weld ¾ inch lugs to the plate to attach the rigging. A finite element structural analysis model of this design shows that the stresses in the tank wall are below 1/3 of the yield strength and the factor of safety of 3 as required by the DOE-STD-1090 reference to ASME B30.20-1.2.2 for "Below the Hook Lifting Devices" is met.</p>				
<b>REVIEW AND APPROVAL SIGNATURES:</b>				
	<b>R/A</b>	<b>TYPED NAME/ORGANIZATION</b>	<b>SIGNATURE</b>	<b>DATE</b>
PREPARED BY:		Lowell Magieby	<i>Herbert L. Magieby</i>	12/3/03
CHECKED BY:		<b>KEVIN SHABER</b>	<i>[Signature]</i>	12/3/03
INDEPENDENT REVIEWER				
APPROVAL:		<b>GARY MECHAN</b>	<i>[Signature]</i>	12/3/03
Distribution:				
<p>Registered Professional Engineer's Stamp (if required)</p> <div style="text-align: center;">  </div>				

EDF Title: **TSF-26 PM2A HALF-TANK LIFTING LUGS DESIGN**  
Project No.: 2000-096  
Project Title: OU 1-10, TSF-26 REMEDIATION  
Prepared by: L. Magleby      Date: 03-Dec-03      Checked by: Kevin Shaber

EDF No. 096-012A  
Rev. No.: 0  
Page 2 of 8  
Date: 03-Dec-03

**PROBLEM STATEMENT:**

TSF-26 Site Remediation Operations require the cutting and removal of the PM2A Tanks [V-13 (East Tank) and V-14 (West Tank)] halves in conjunction with waste removal operations.

Design lifting lugs with tank reinforcing pads that can be welded to the PM-2A top and bottom half tanks and used to attach the rigging to lift the half tanks. This is an alternate method

The half tanks each weigh 33,425 lbs. The half tanks are to be lifted with a mobile crane using a single hook. The tanks are to be rigged near the two end internal rib stiffeners of the tank each located about 11 feet from their respective ends. The rigging will use a spreader bar so that the lifting points will be directly above the rigging location at the stiffeners. The length of the rigging from the spreader bar to the tank will be of a length so that the angle of the rigging from the lugs welded to each side of the tank, about 12 ½ feet apart, to the attachment points on the spreader will be about 35° from vertical.

**ASSUMPTIONS:**

The Assumptions utilized in the performance of these calculations are outlined below:

- Thickness of the PM2A Tank walls to be 5/8"
- Thickness of PM2A Tank Exterior TAR Coating was confirmed to be 1/16" and NOT the previously reported 1'2" to 1" thickness range.
- Calculated Weight of the PM2A Tank Half is 33,425 pounds

**REFERENCES:**

EDF-0960012 Rev.2  
DOE-ID Order 440C  
DOE-STD-1090-2001  
ASME B30.20a-2001

**ACCEPTANCE CRITERIA:**

The stresses in the tank wall will be less than 1/3 of yield stress to meet the intent of the DOE-STD-1090 reference to ASMEB30.20a. The design of the pads to be welded to the tank wall and the lifting lugs will have a factor of safety of 3 to be in compliance with the DOE-STD-1090 reference to ASMEB30.20a.

**DESCRIPTION OF DESIGN:**

The design is shown on Drawing M-6 included in the design submittal and is shown on the attached sketch. The design is to weld a ½ inch steel plate 2 ft long by 1 ft high to the outside surface of the half tanks at the location of the rigging points at the end stiffeners located about 11 feet from their respective ends. Lifting lugs fabricated from ¾ inch steel plate are welded to the ½ inch steel plate at the rigging attachment plates. The lifting lugs are sized for attaching 1 inch shackles.

**DESCRIPTION OF ANALYSIS:**

A three dimensional finite element model was made of the plate attachment to the tank outer surface using the RISA 3D structural analysis program. The support of the plate by the tank wall was approximated by modeling a section of the tank wall one foot greater than the size of the plate at each side and fixing the outer edges. Flat plates were used in the model to simplify the modeling but curved plates would be expected to be stronger; therefore, the model is considered to be conservative. The model is rather coarse in that the number of flat plates used to formulate the model is not large. However, care was taken in formulating the model to assure that there were sufficient plates so that parts were connected by at least the node points. The model is shown in the attachment titled RISA 3D Analysis.

The design is the same for the top half tank and the bottom half tank. However, the direction of the load is away from the free edge for lifting the top half tank and towards the free edge for the bottom half tank. Analyses were made with the force in both directions.

The lifting lug was analyzed manually as was done in the design of the lugs for the spreader bar. See the EDF 096-012 included in the Design Submittal. The analyses for the lug for this application are included in the Attachment Lifting Lug Analysis.

**ANALYSIS RESULTS:**

The results of the analyses are shown in the attached table, Results of Analyses of Half Tank Lifting Lugs for PM-2A Rigging. The stresses were higher for the bottom half tank with the lifting force towards the free edge. The results are in the table for this case. The complete RISA 3D results for both cases are included in the attached RISA 3D Analysis. The RISA 3D results given in the results table only gives the stresses at the center of the small plates used to formulate the model. The highest stresses usually occur at the edges of the small plates. The contour plots of the results provided by RISA 3D show extrapolation of the stresses to all points in the model. The stresses for the half tank wall and the ½ inch plate welded to the half tank were taken from the counter plots. Narrow ½ plates were used to model the welds between the half tank wall and the ½ inch plate and the stress at the center of these narrow plates from the results table were used for the welds.

The result is the table showing that the acceptance criteria are met and the design is acceptable.

***Results of Analyses of Half Tank Lifting Lugs for PM-2A Rigging***

<b>PART</b>	<b>ACCEPTANCE REFERENCE</b>	<b>SPECIFIED ACCEPTANCE</b>	<b>BASIS FOR SAFETY FACTOR</b>	<b>CALCULATE STRESS</b>	<b>SAFETY FACTOR</b>
Half tank wall	Intent of DOE-STD-1090 14.2.1 which invokes ASMEB30,20-1.2.2	Safety factor of three based on yield strength	$F_y = 36$ ksi	Von Mises Stress = 11.7 ksi	3.08
½ in. plate	DOE-STD-1090 14.2.1 which invokes ASMEB30,20-1.2.2	Safety factor of three based on yield strength	$F_y = 36$ ksi	Von Mises Stress = 11.7 ksi	3.08
Weld of ½ in plate to half tank wall	*AISC Manual of Steel Construction J2.2	$0.3 F_u$	21.0 ksi	Max shear stress = 3.63 ksi	5.78
Lifting lug Tension stress	DOE-STD-1090 14.2.1 which invokes ASMEB30,20-1.2.2	Safety factor of three based on yield strength	$F_y = 36$ ksi	3.04 ksi	11.84
Lifting lug bearing stress	*AISC Manual of Steel Construction J3.7	$F_p = L_e F_u / 2d$	51.6 ksi	12.09 ksi	4.27
Lifting lug fillet weld	*AISC Manual of Steel Construction J2.2	$0.3 F_u$	21.0 ksi	3.06	6.86

\* DOE-STD-1090 Section 14.2.1 invokes ASME B30.20-1.2.2 which specifies a safety factor of 3 based on yield stress. The allowable values for the stresses for the items marked with an asterisks are not usually based on the yield stress; therefore, the allowable values for these stresses from the AISC Manual of Steel Construction were used but the requirement used in the design was that the safety factor based on these stress must be greater than 3.



# INEEL BBW1 RFP-394 RD/RA Work Plan for WAG 1-10 ==> Crane Lifting / Loading Calculations

## WAG 1-10 Sites TSF-26, TSF-03, and WRTTF-01

INTREPID prepared Revision 0 dated - 13-Jan-2003, by DJ Kenoyer, Checked by SD Dustin



1 Revision 1, 24-Feb-03, by DJ Kenoyer

2 Revision 2, 15-Jul-03, by DJ Kenoyer

3 100% Rev 1, 28-Jul-03, by DJ Kenoyer / Changed Tank Thickness to be MORE Conservative to 1/4" from 3/16"

4 Draft FINAL, 29-Sep-03 by DJ Kenoyer / Changed Tank Thickness from 1/4" to the 1/2" found during September 2003 Tank Sampling efforts by BBW1

5 07-Nov-03 by DJ Kenoyer / Tank Exterior Tar Coating Thickness from 1/2" to 1" found during September 2003 Tank Sampling efforts by BBW1

6 20-Nov-03 by DJ Kenoyer / Tank Exterior Tar Coating Thickness 1/16" confirmed by BBW1 ==> NOT 1/2" to 1" as reported earlier

7 01-Dec-03 by DJ Kenoyer / Tank Steel thickness 5/8" confirmed by BBW1 ==> NOT 1/2" as reported earlier [Revision 4]

### Original Configuration

Description	diameter (lineal feet)	length	depth	Area (square feet)	Thickness (inches)	Unit (lbs/cf)	Weight		Total (lbs)	Half-PM2A (lbs)
							Tank (lbs)	Added (lbs)		
Weight Calculations										
7					5/8	25.60	61,575	4,310	65,885	32,943 7
7 Specific Weight of "TAR"	72 lbs per cubic foot				0.06	0.38	902	63	965	483 6
										33,425 7 & 6
					1/2	20.40	49,068	3,435	52,502	26,251 4
Specific Weight of "TAR"	72 lbs per cubic foot				0.06	0.38	902	63	965	483 6
										26,734 4 & 6
PM2A Tank	12.5	55.0		2,405.3	3/8	15.30	36,801	2,576	39,377	19,688
					5/16	12.80	30,788	2,155	32,943	16,471
Assume Tank Ribs and Manways ==>	7.0% Added Weight				1/4	10.20	24,534	1,717	26,251	13,126 3
					3/16	7.65	18,400	1,288	19,688	9,844
					1/8	5.10	12,267	859	13,126	6,563

Description	width (lineal feet)	length (lineal feet)	height (lineal feet)	Length (lineal feet)	Width (lineal feet)	Unit (lbs/cf)	Weight		Total (lbs)
							TEA (lbs)	Added (lbs)	
2 Weight Calculations for RUBB THA Shelter									
THA 8 Meter	26.2	65.0		40.0	26.2		5,050		5,050
				25.0		71.00		1,775	1,775
				Percentage Contingency for Added Weight Associated with Lifting System ==>				5.0%	<u>350</u>
									<u>7,175</u>
2 Weight Calculations for RUBB Special Shelter									
THA 22'0" Walls	16.0	35.0		35.0	16.0	8.0	4,480		4,500
								5.0%	<u>230</u>
									<u>4,730</u>

Description	width (lineal feet)	length (lineal feet)	thickness (lineal feet)	Volume (cubic feet)	Unit (lbs/cf)	Weight		Total (lbs)
						Precast (lbs)	Added (lbs)	
2 Weight Calculations for Precast "C" Section Shielding Concrete								
Sides	2	6.0	9.8	87.8	145.0	12,724		12,724
End	1	6.0	13.8	62.2	145.0	9,024		9,024
Percentage Contingency for Added Steel Reinforcing ==>							4.5%	980
								22,728

### Technical Specifications for Grove Mobile Hydraulic Crane GMK5240 [240 ton crane]

Boom Extension	Boom Angle	Lift Capacity	52,502	26,251
				26,734 4 & 6
			(lbs)	(lbs)
(h-lineal feet) (h-lineal feet)	(degrees)	(lbs)	Percent Lift Capacity	
105.0 80.0	40.4	53,000	99.1%	49.5%
121.0 100.0	34.3	36,000	145.8%	72.9%
136.0 110.0	36.0	32,200		
151.0 120.0	37.4	24,800		
Distance from C/L Crane to C/L of Load = (h-lineal feet)				

Distance from C/L Crane to C/L of Load ==> (h-lineal feet)

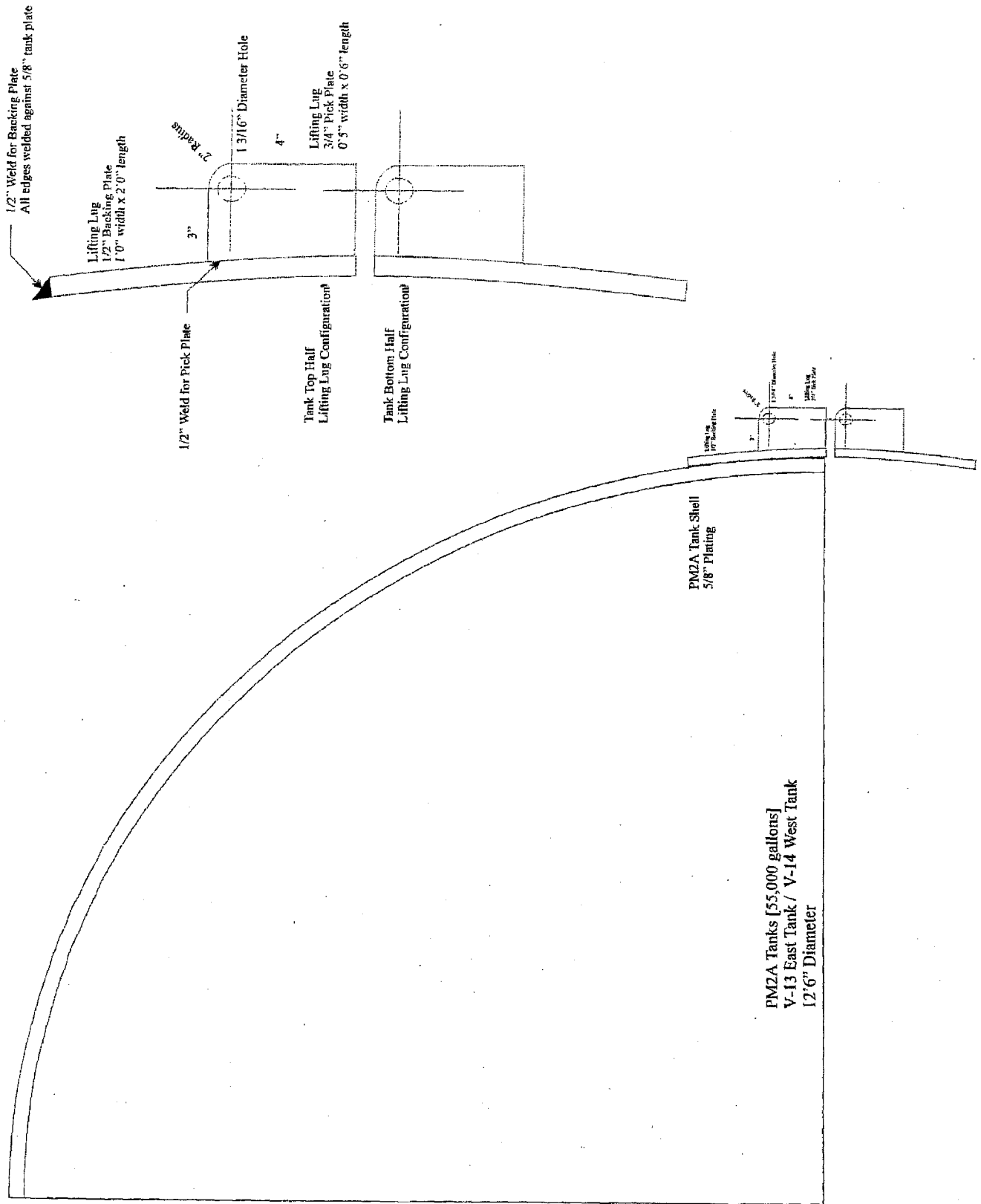
				Horizontal Distance - Crane to Tank		Lift Capacity	Percent Loading
Grove 5240 Counterweights	154,300 pounds	V-13	East Tank	80.0	h-linal feet	53,000	49.5% 4
Outrigger Status - Extensions	100% 27'3" Spread	V-14	West Tank	100.0	h-linal feet	36,000	72.9% 4
Crane Rotation Status	360 degrees	RUBB THA 26.2' x 65.0		110.0	h-linal feet	7,175	22.3% 4
		Precast "C" Shape		110.0	h-linal feet	22,728	32,200 70.6%

Long High Capacity Trailers Available ==> 2003 Fontaine Specialized TDFT Telescopic Step, Drop Deck Extendable

102" wide / 48'-69' deck / 80,000 lbs capacity

Horizontal Distance - Crane to Tank				Lift Capacity	Percent Loading
V-13	East Tank	80.0	h-lineal feet	53,000	50.4% 4 & 6
V-14	West Tank	100.0	h-lineal feet	36,000	74.3% 4 & 6
RUBB THA	26.2' x 65.0	110.0	h-lineal feet	7,175	22.3%
Precast "C" Shape		110.0	h-lineal feet	22,728	70.6%

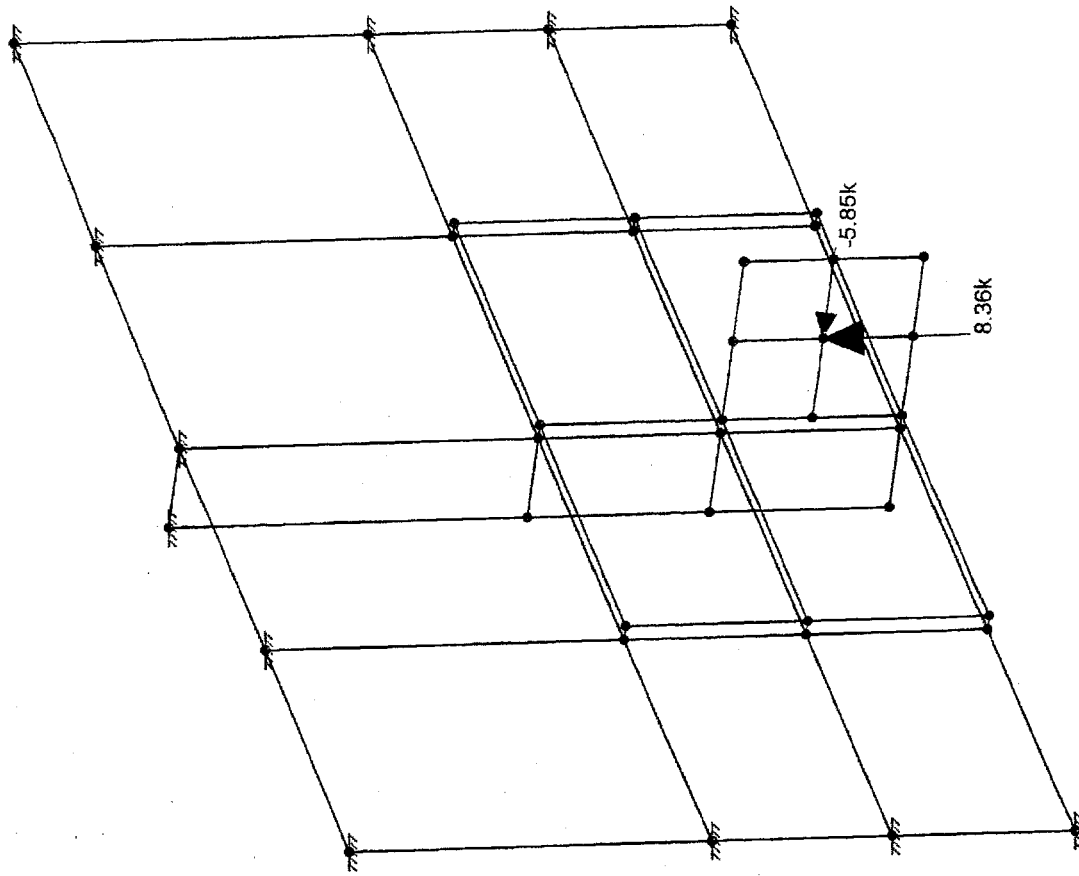
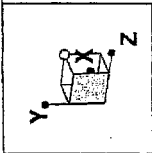
Horizontal Distance - Crane to Tank				Lift Capacity	Percent Loading
V-13	East Tank	80.0	h-lineal feet	53,000	63.1% 7 & 6
V-14	West Tank	100.0	h-lineal feet	36,000	92.8% 7 & 6
RUBB THA	26.2' x 65.0	110.0	h-lineal feet	7,175	22.3%
Precast "C" Shape		110.0	h-lineal feet	22,728	70.6%



## RISA 35 ANALYSIS

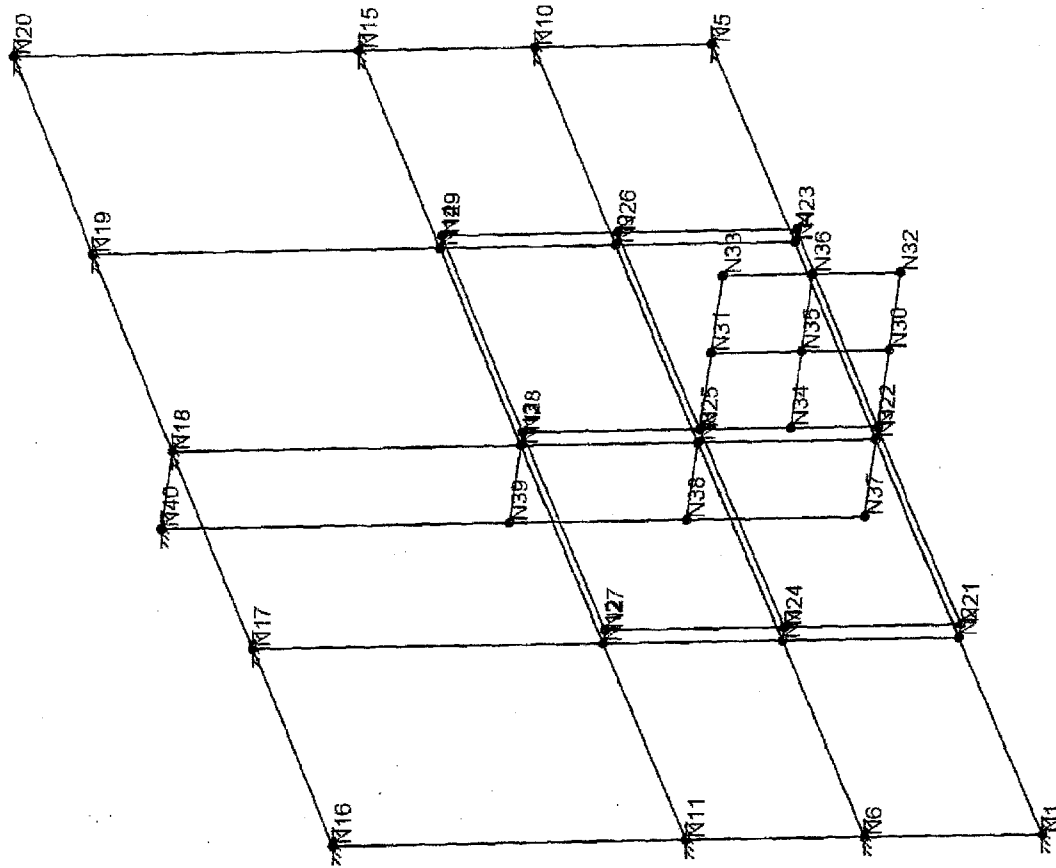
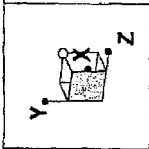
RISA 3D ANALYSIS

UPPER HALF TANK



Loads: BLC 2, Results for LC 2, Upper Half 5/8 wall	
Intrepid Technology and Resources, ..	
ITR	

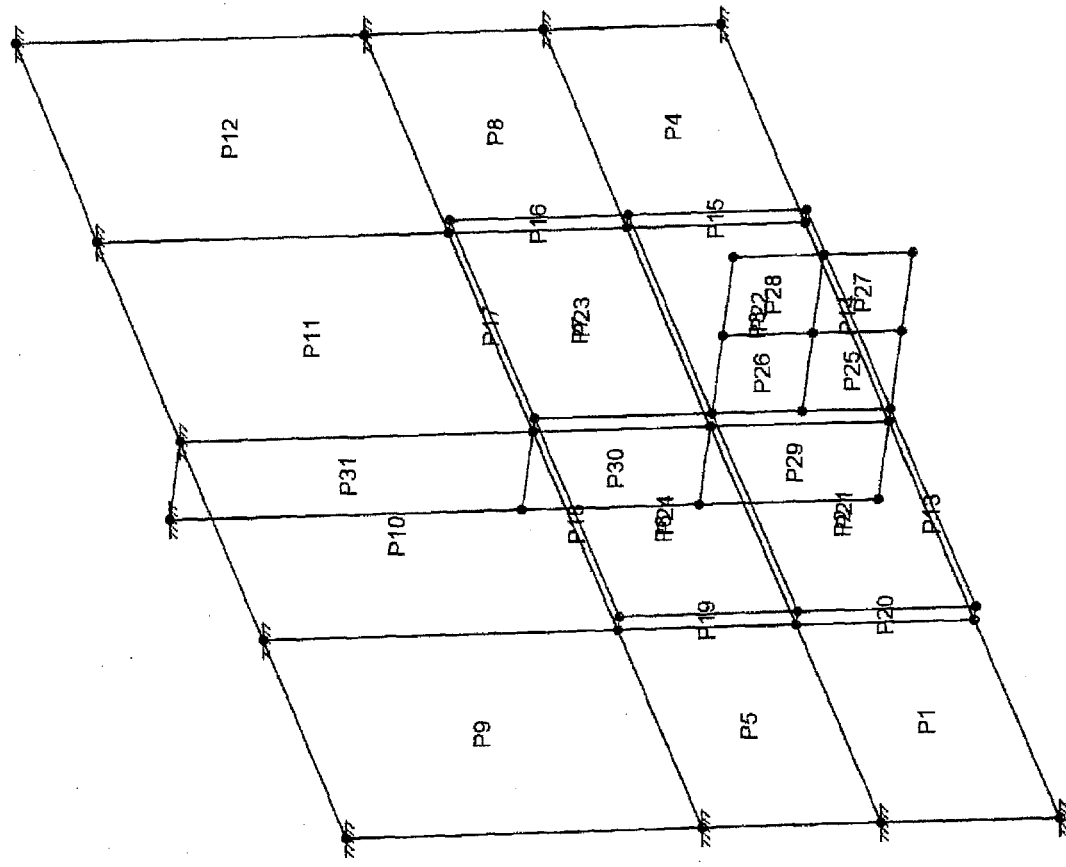
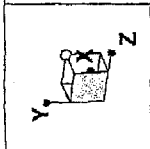
PM-2A Tank Lug	
December 2, 2003	
6:00 PM	
Tank lift pad .625 wall.r3d	



Results for LC 2, Upper Half 5/8 wall
Intrepid Technology and Resources, ..
ITR

December 2, 2003
6:03 PM
Tank lift pad .625 wall.r3d

PM-2A Tank Lug



Results for LC 2, Upper Half 5/8 wall	PM-2A Tank Lug		December 2, 2003
Intrepid Technology and Resources, ..			6:05 PM
ITR			Tank lift pad, 625 wall.r3d

Company : Intrepid Technology and Resources, Inc.  
 Designer : ITR  
 Job Number : PM-2A Tank Lug

December 2, 2003  
 6:21 PM  
 Checked By: \_\_\_\_\_

### Joint Coordinates

Joint Label	X Coordinate (in)	Y Coordinate (in)	Z Coordinate (in)	Joint Temperature (F)	Detach from Diaphragm
N1	0	0	0	0	No
N2	12	0	0	0	No
N3	24	0	0	0	No
N4	36	0	0	0	No
N5	48	0	0	0	No
N6	0	6	0	0	No
N7	12	6	0	0	No
N8	24	6	0	0	No
N9	36	6	0	0	No
N10	48	6	0	0	No
N11	0	12	0	0	No
N12	12	12	0	0	No
N13	24	12	0	0	No
N14	36	12	0	0	No
N15	48	12	0	0	No
N16	0	24	0	0	No
N17	12	24	0	0	No
N18	24	24	0	0	No
N19	36	24	0	0	No
N20	48	24	0	0	No
N21	12	0	.5	0	No
N22	24	0	.5	0	No
N23	36	0	.5	0	No
N24	12	6	.5	0	No
N25	24	6	.5	0	No
N26	36	6	.5	0	No
N27	12	12	.5	0	No
N28	24	12	.5	0	No
N29	36	12	.5	0	No
N30	24	0	3.5	0	No
N31	24	6	3.5	0	No
N32	24	0	6.5	0	No
N33	24	6	6.5	0	No
N34	24	3	.5	0	No
N35	24	3	3.5	0	No
N36	24	3	6.5	0	No
N37	24	0	-3	0	No
N38	24	6	-3	0	No
N39	24	12	-3	0	No
N40	24	24	-3	0	No



Company : Intrepid Technology and Resources, Inc.  
 Designer : ITR  
 Job Number : PM-2A Tank Lug

December 2, 2003  
 6:22 PM  
 Checked By: \_\_\_\_\_

### Plate/Shell Elements

Plate Label	A Joint	B Joint	C Joint	D Joint	Material Set	Thickness (in)	Stress Location 'R'	'S'	Inactive?
P1	N1	N6	N7	N2	STL	.625	0	0	
P2	N2	N7	N8	N3	STL	.625	0	0	
P3	N3	N8	N9	N4	STL	.625	0	0	
P4	N4	N9	N10	N5	STL	.625	0	0	
P5	N6	N11	N12	N7	STL	.625	0	0	
P6	N7	N12	N13	N8	STL	.625	0	0	
P7	N8	N13	N14	N9	STL	.625	0	0	
P8	N9	N14	N15	N10	STL	.625	0	0	
P9	N11	N16	N17	N12	STL	.625	0	0	
P10	N12	N17	N18	N13	STL	.625	0	0	
P11	N13	N18	N19	N14	STL	.625	0	0	
P12	N14	N19	N20	N15	STL	.625	0	0	
P13	N21	N2	N3	N22	STL	.625	0	0	
P14	N22	N3	N4	N23	STL	.625	0	0	
P15	N23	N4	N9	N26	STL	.625	0	0	
P16	N26	N9	N14	N29	STL	.625	0	0	
P17	N28	N13	N14	N29	STL	.625	0	0	
P18	N27	N12	N13	N28	STL	.625	0	0	
P19	N24	N7	N12	N27	STL	.625	0	0	
P20	N21	N2	N7	N24	STL	.625	0	0	
P21	N21	N22	N25	N24	STL	.625	0	0	
P22	N22	N23	N26	N25	STL	.625	0	0	
P23	N25	N26	N29	N28	STL	.625	0	0	
P24	N24	N25	N28	N27	STL	.625	0	0	
P25	N30	N22	N34	N35	STL	.75	0	0	
P26	N35	N34	N25	N31	STL	.75	0	0	
P27	N32	N30	N35	N36	STL	.75	0	0	
P28	N36	N35	N31	N33	STL	.75	0	0	
P29	N3	N37	N38	N8	STL	1	0	0	
P30	N8	N38	N39	N13	STL	1	0	0	
P31	N13	N39	N40	N18	STL	1	0	0	

Company : Intrepid Technology and Resources, Inc.  
Designer : ITR  
Job Number : PM-2A Tank Lug

December 2, 2003  
6:22 PM  
Checked By: \_\_\_\_\_

---

**Joint Loads/Enforced Displacements, Category : None, BLC 1 : Lower Half 5/8 wall**

---

Joint Label	[L]oad,[M]ass,or [D]isplacement	Direction	Magnitude (k, k-in, in, rad, k*s^2/in)
N35	L	Y	-10.2
N35	L	Z	-5.85

**Reactions, By Combination**

LC	Joint Label	X Force (k)	Y Force (k)	Z Force (k)	X Moment (k-in)	Y Moment (k-in)	Z Moment (k-in)
2	N1	.919	.425	.449	.024	-2.887	0
2	N6	.831	-.311	.207	-.101	-1.224	0
2	N11	.83	-.251	.002	-.125	-.559	0
2	N16	.215	-.174	.048	-.238	-.262	0
2	N17	-.01	-.195	.158	-1.434	-.158	0
2	N18	0	11.849	-.498	-3.133	0	0
2	N40	0	-19.199	4.618	0	0	0
2	N19	.01	-.195	.158	-1.434	.158	0
2	N20	-.215	-.174	.048	-.238	.262	0
2	N15	-.83	-.251	.002	-.125	.559	0
2	N10	-.831	-.311	.207	-.101	1.224	0
2	N5	-.919	.425	.449	.024	2.887	0
2	Totals:	0	-8.36	5.85			
2	COG (in):	X: 24	Y: 3	Z: 3.5			

Company : Intrepid Technology and Resources, Inc.  
 Designer : ITR  
 Job Number :

PM-2A Tank Lug

December 2, 2003  
 6:24 PM  
 Checked By:

**Plate/Shell Principal Stresses, By Combination**

LC	Plate Label	Surface [T]op / [B]ottom	Sigma1 (ksi)	Sigma2 (ksi)	Tau Max (ksi)	Angle (radians)	Von Mises (ksi)
2	P1	T	.63	.054	.288	-.614	.605
		B	-.334	-1.225	.445	-.152	1.097
2	P2	T	-.319	-.632	.156	.705	.547
		B	1.33	.64	.345	.21	1.152
2	P3	T	-.319	-.632	.156	-.705	.547
		B	1.33	.64	.345	-.21	1.152
2	P4	T	.63	.054	.288	.614	.605
		B	-.334	-1.225	.445	.152	1.097
2	P5	T	.331	.053	.139	-.554	.308
		B	.06	-.882	.471	-.395	.914
2	P6	T	.194	-.211	.202	.325	.351
		B	1.114	.312	.401	.568	.995
2	P7	T	.194	-.211	.202	-.325	.351
		B	1.114	.312	.401	-.568	.995
2	P8	T	.331	.053	.139	.554	.308
		B	.06	-.882	.471	.395	.914
2	P9	T	.282	.083	.1	.707	.251
		B	-.124	-.415	.146	-.733	.369
2	P10	T	.458	.004	.227	.212	.456
		B	.098	-.523	.311	.243	.579
2	P11	T	.458	.004	.227	-.212	.456
		B	.098	-.523	.311	-.243	.579
2	P12	T	.282	.083	.1	-.707	.251
		B	-.124	-.415	.146	.733	.369
2	P13	T	-1.957	-7.15	2.597	.236	6.4
		B	6.693	1.539	2.577	-.197	6.072
2	P14	T	-1.957	-7.15	2.597	-.236	6.4
		B	6.693	1.539	2.577	.197	6.072
2	P15	T	-.766	-3.01	1.122	.126	2.71
		B	3.09	1.048	1.021	-.104	2.722
2	P16	T	-.875	-3.517	1.321	.026	3.171
		B	4.035	1.207	1.414	-.248	3.587
2	P17	T	5.353	1.472	1.941	.055	4.79
		B	-1.816	-6.048	2.116	-.134	5.375
2	P18	T	5.353	1.472	1.941	-.055	4.79
		B	-1.816	-6.048	2.116	.134	5.375
2	P19	T	4.035	1.207	1.414	-.248	3.587
		B	-.875	-3.517	1.321	.026	3.171
2	P20	T	3.09	1.048	1.021	-.104	2.722
		B	-.766	-3.01	1.122	.126	2.71
2	P21	T	.878	.403	.237	.152	.761
		B	-1.444	-2.078	.317	.367	1.844
2	P22	T	.878	.403	.237	-.152	.761
		B	-1.444	-2.078	.317	-.367	1.844
2	P23	T	.22	-.38	.3	.556	.525
		B	-.948	-2.172	.612	.782	1.886
2	P24	T	.22	-.38	.3	-.556	.525
		B	-.948	-2.172	.612	-.782	1.886
2	P25	T	1.588	-.428	1.008	-.539	1.84
		B	1.588	-.428	1.008	-.539	1.84
2	P26	T	.396	-5.282	2.839	-.739	5.491
		B	.396	-5.282	2.839	-.739	5.491
2	P27	T	.344	-.317	.331	-.77	.573
		B	.344	-.317	.331	-.77	.573
2	P28	T	.151	-.649	.4	.486	.736
		B	.151	-.649	.4	.486	.736

Company : Intrepid Technology and Resources, Inc.  
 Designer : ITR  
 Job Number : PM-2A Tank Lug

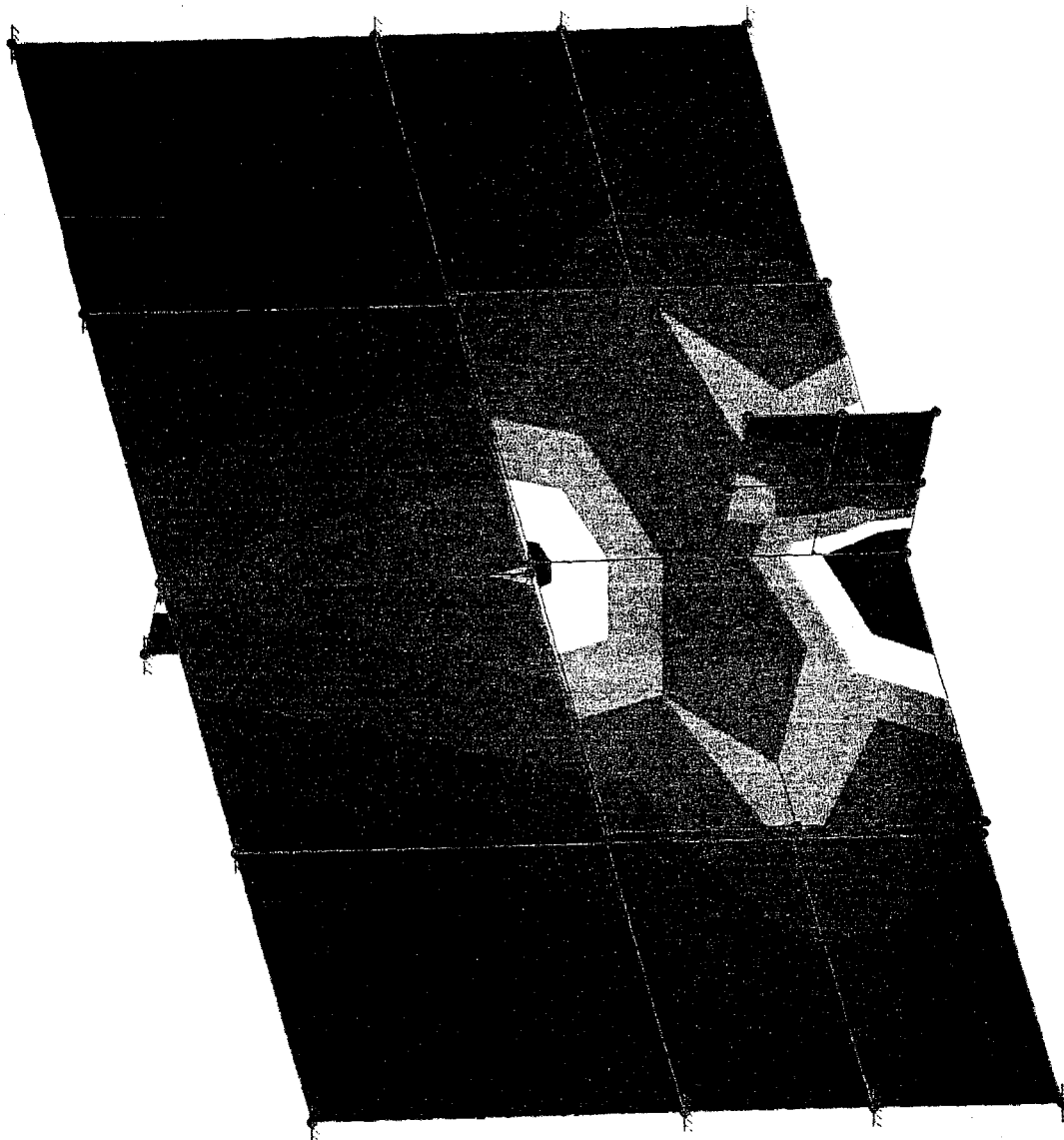
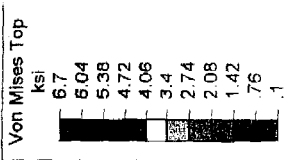
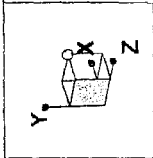
December 2, 2003  
 6:24 PM  
 Checked By: \_\_\_\_\_

***Plate/Shell Principal Stresses, By Combination, (continued)***

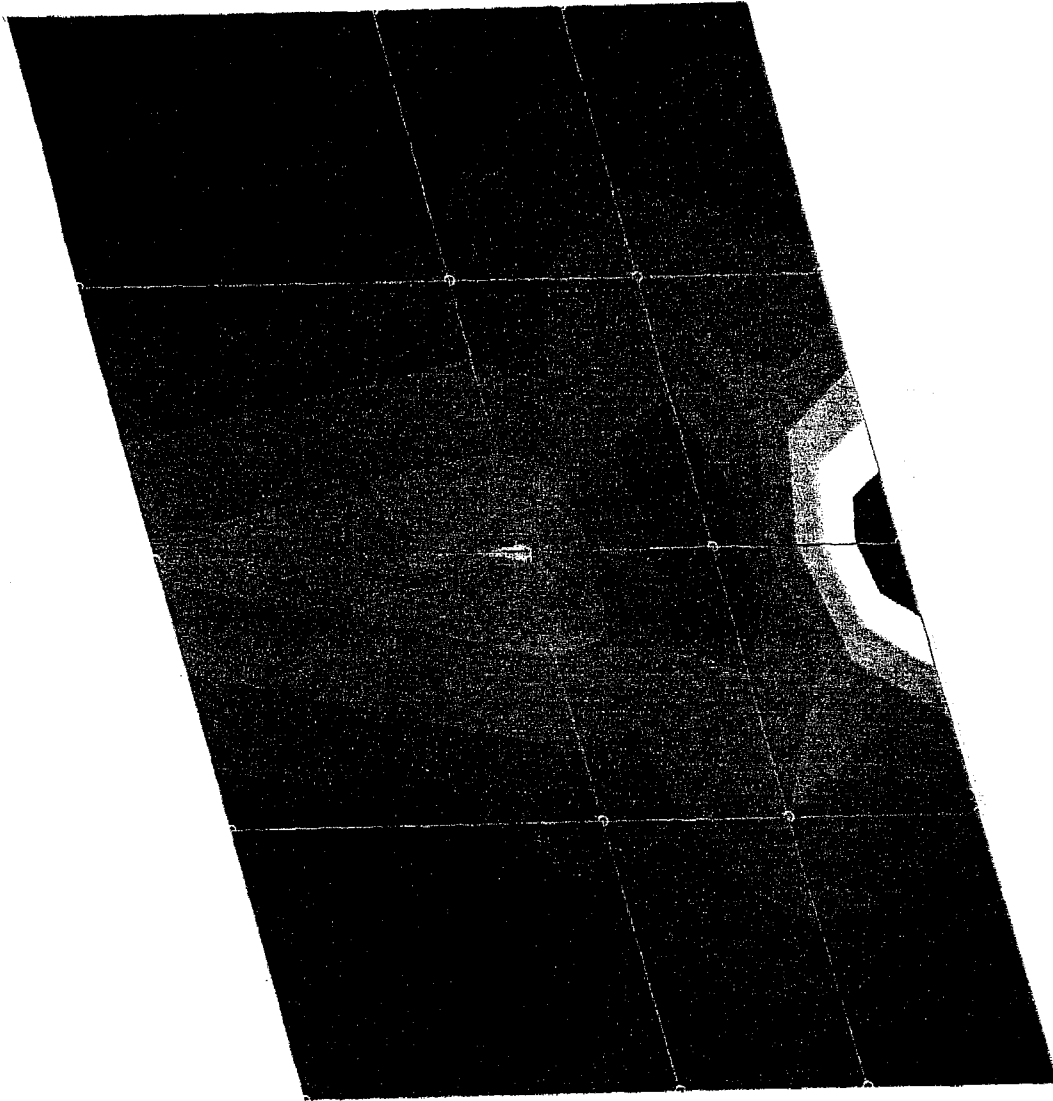
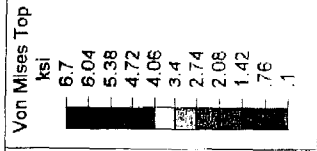
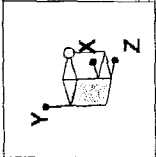
LC	Plate Label	Surface [T]op / [B]ottom	Sigma1 (ksi)	Sigma2 (ksi)	Tau Max (ksi)	Angle (radians)	Von Mises (ksi)
2	P29	T	.456	-.272	.364	.539	.637
		B	.456	-.272	.364	.539	.637
2	P30	T	.891	-1.324	1.108	.719	1.931
		B	.891	-1.324	1.108	.719	1.931
2	P31	T	.239	-2.981	1.61	.426	3.108
		B	.239	-2.981	1.61	.426	3.108

**Plate/Shell Forces, By Combination**

LC	Plate Label	Qx (k/in)	Qy (k/in)	Mx (k-in/in)	My (k-in/in)	Mxy (k-in/in)	Fx (k/in)	Fy (k/in)	Fxy (k/in)
2	P1	.004	.11	.02	.054	.013	-.034	-.239	.043
2	P2	.129	-.078	-.036	-.059	.01	.069	.25	.004
2	P3	.129	.078	-.036	-.059	-.01	.069	.25	-.004
2	P4	.004	-.11	.02	.054	-.013	-.034	-.239	-.043
2	P5	-.008	-.005	.007	.032	.015	.016	-.153	-.066
2	P6	-.119	-.007	-.013	-.034	.016	.218	.223	-.075
2	P7	-.119	.007	-.013	-.034	-.016	.218	.223	.075
2	P8	-.008	.005	.007	.032	-.015	.016	-.153	.066
2	P9	.006	.007	.015	.015	.008	-.018	-.037	-.015
2	P10	.032	-.002	.03	-.001	.008	-.015	.027	-.016
2	P11	.032	.002	.03	-.001	-.008	-.015	.027	.016
2	P12	.006	-.007	.015	.015	-.008	-.018	-.037	.015
2	P13	.066	-.006	-.435	-.129	-.006	-.116	-.157	-.678
2	P14	.066	.006	-.435	-.129	.006	-.116	-.157	.678
2	P15	.94	-.035	-.197	-.061	-.002	.029	.084	-.153
2	P16	.541	.039	-.24	-.073	.02	.109	.156	-.232
2	P17	-.607	-.013	.368	.11	-.011	-.197	-.127	.243
2	P18	-.607	.013	.368	.11	.011	-.197	-.127	-.243
2	P19	-.541	-.039	.24	.073	-.02	.109	.156	-.232
2	P20	-.94	.035	.197	.061	.002	.029	.084	-.153
2	P21	.089	-.176	.078	.078	.005	-.494	-.206	-.089
2	P22	-.089	-.176	.078	.078	-.005	-.494	-.206	.089
2	P23	-.068	.188	.053	.044	.029	-.472	-.553	-.107
2	P24	.068	.188	.053	.044	-.029	-.472	-.553	.107
2	P25	0	0	0	0	0	.078	.792	.666
2	P26	0	0	0	0	0	-2.028	-1.637	2.12
2	P27	0	0	0	0	0	.018	.003	-.248
2	P28	0	0	0	0	0	-.018	-.356	.248
2	P29	0	0	0	0	0	-.08	.264	-.32
2	P30	0	0	0	0	0	-.07	-.363	1.098
2	P31	0	0	0	0	0	-.31	-2.432	1.211



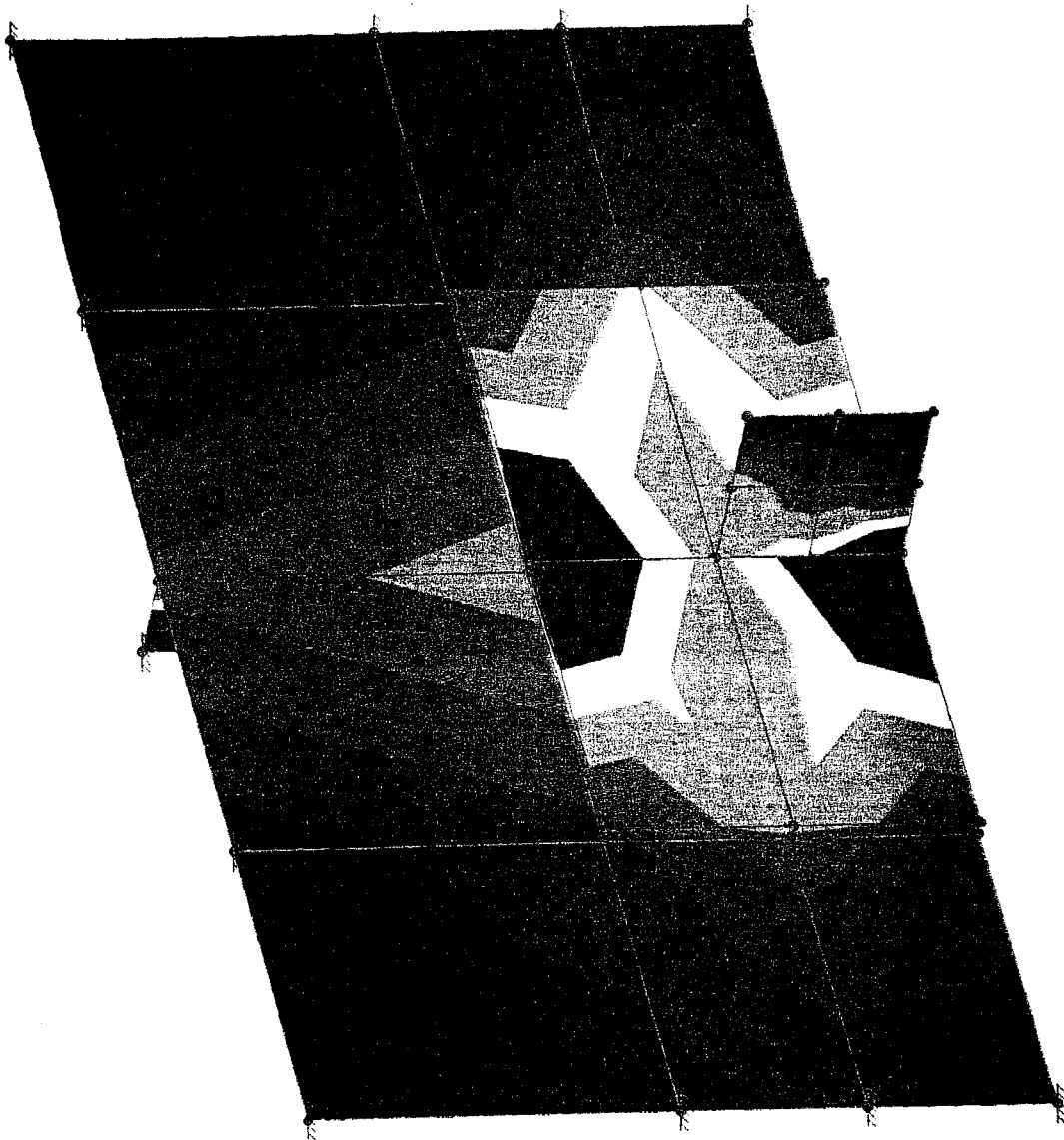
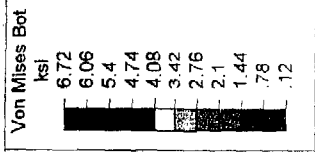
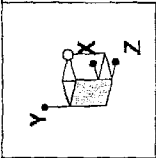
Results for LC 2, Upper Half 5/8 wall	PM-2A Tank Lug	December 2, 2003	
Intrepid Technology and Resources, ...		6:14 PM	
ITR		Tank lift pad .625 wall.r3d	



Results for LC 2, Upper Half 5/8 wall
Intrepid Technology and Resources, ...
ITR

PM-2A Tank Lug <i>Tank wall only</i>	December 2, 2003
	6:17 PM
	Tank lift pad .625 wall.r3d





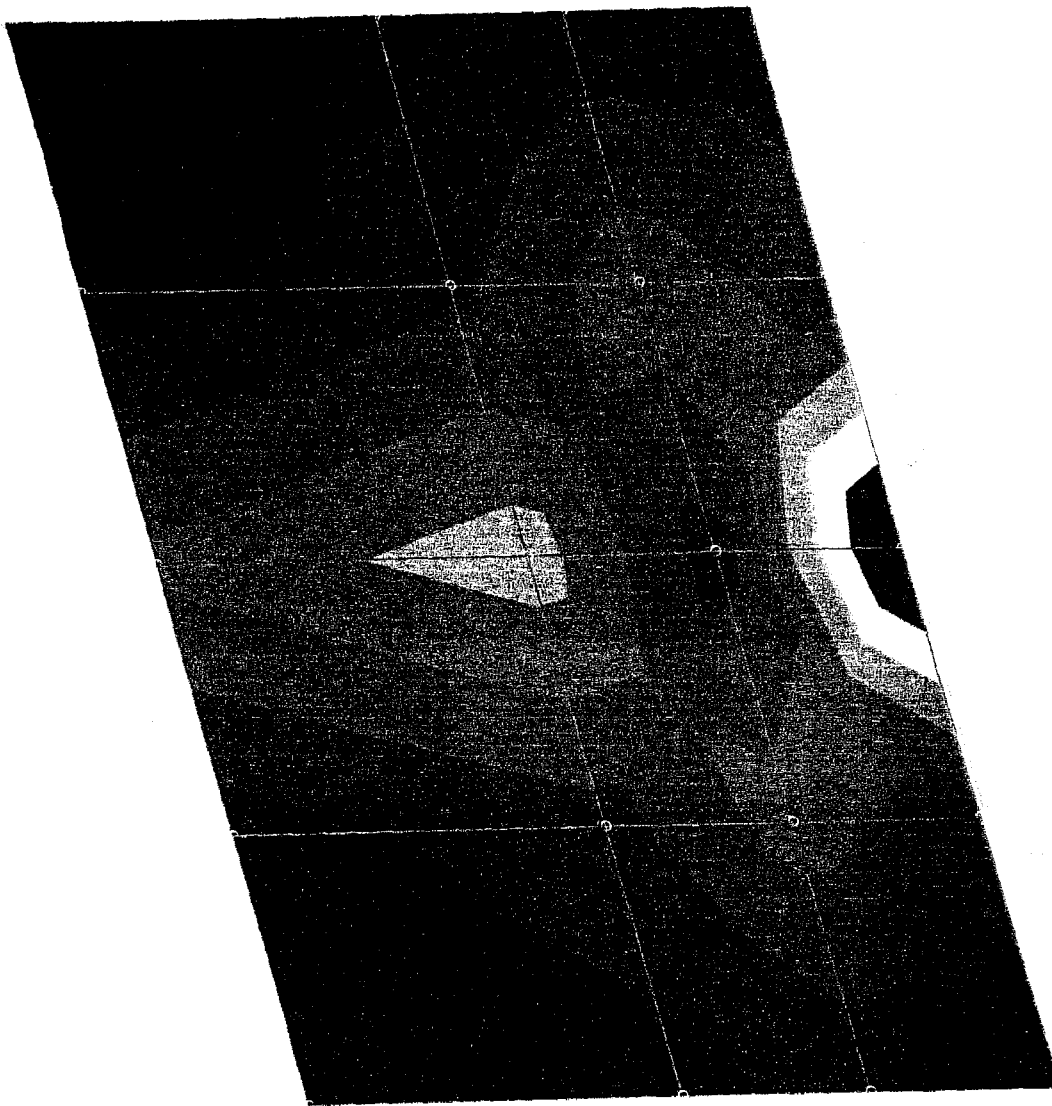
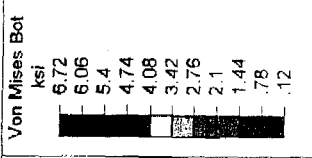
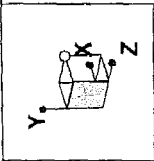
Results for LC 2, Upper Half 5/8 wall
Intrepid Technology and Resources, ...
ITR

PM-2A Tank Lug

December 2, 2003

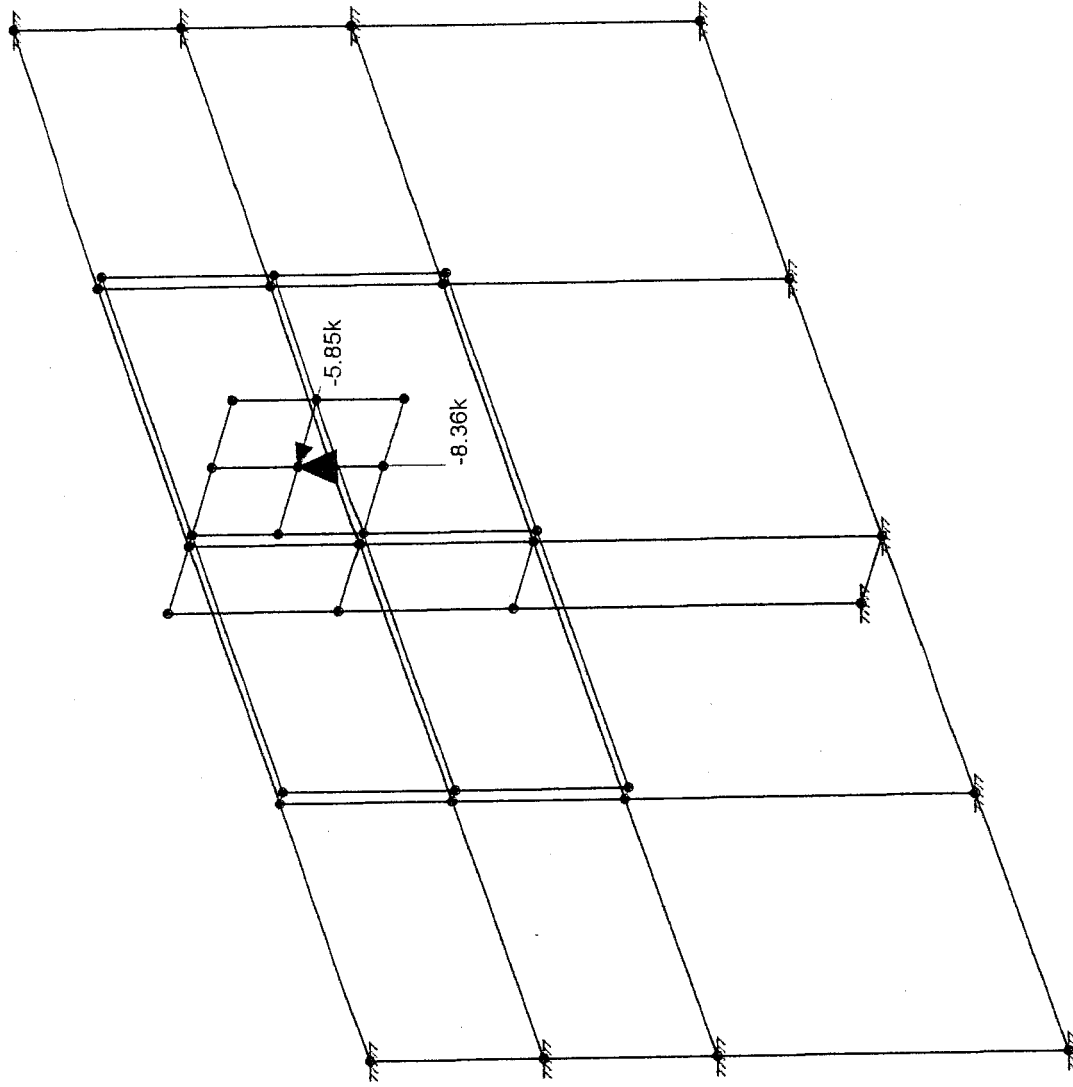
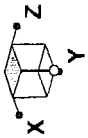
6:19 PM

Tank lift pad .625 wall.r3d



Results for LC 2, Upper Half 5/8 wall	PM-2A Tank Lug <i>Tank wall only</i>	December 2, 2003
Intrepid Technology and Resources, ...		6:11 PM
ITR		Tank lift pad .625 wall.r3d

RISA 3D ANALYSIS  
LOWER HALF TANK



Loads: LC 1, Lower Half 5/8 wall

Intrepid Technology and Resources, ...

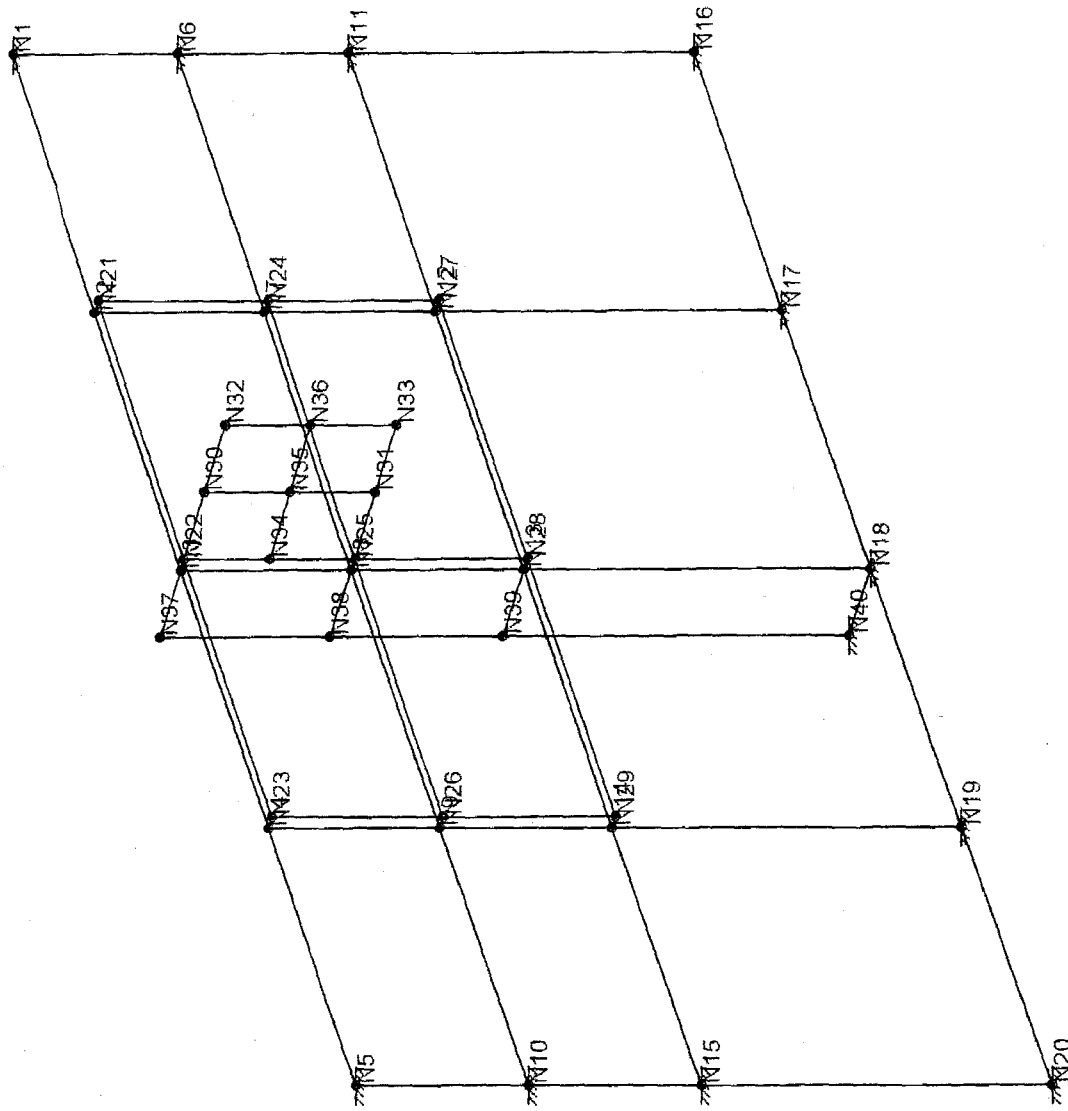
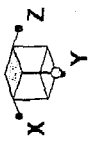
ITR

PM-2A Tank Lug

December 2, 2003

6:32 PM

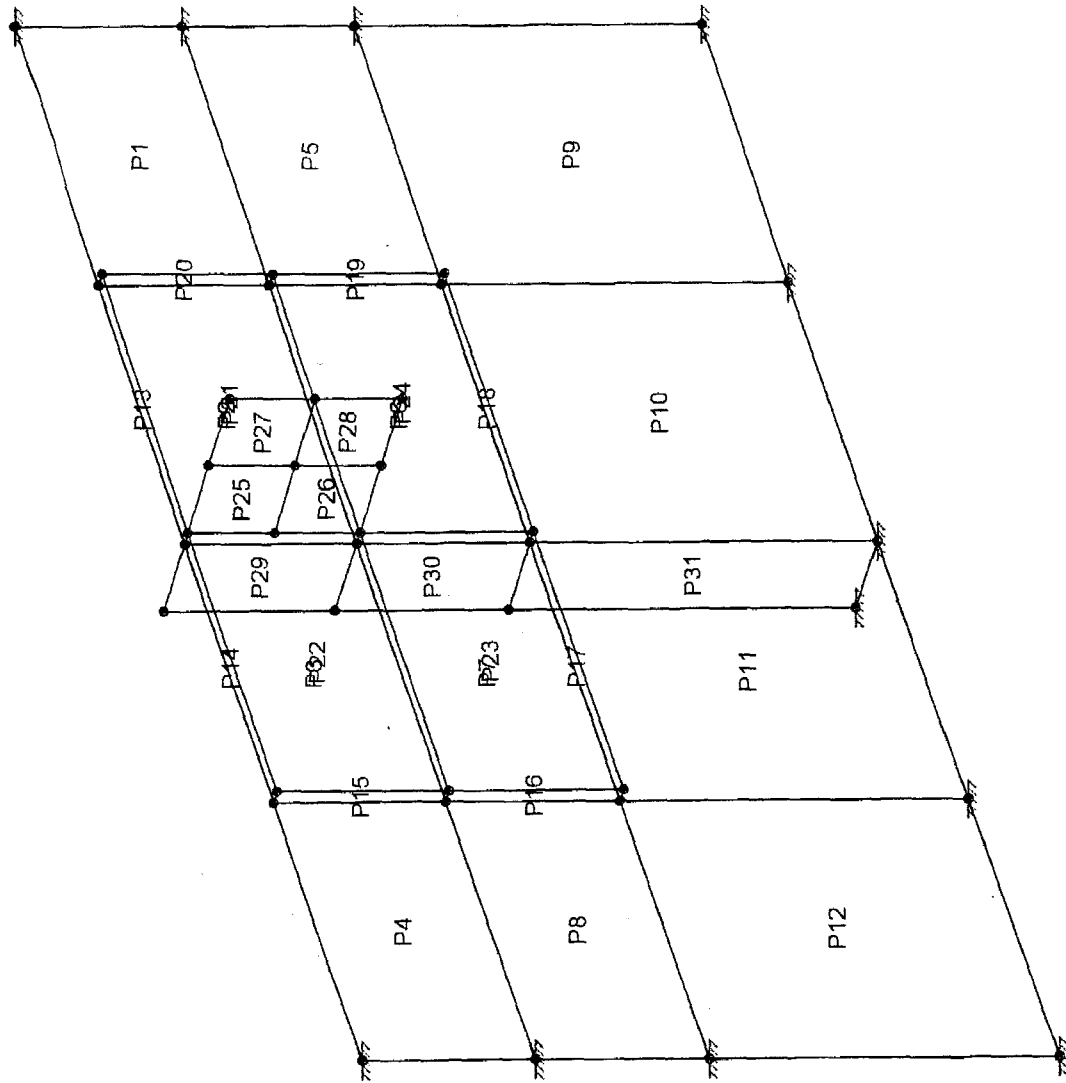
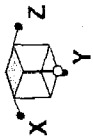
Tank lift pad 625 wall.r3d



Intrepid Technology and Resources, ...	
ITR	

PM-2A Tank Lug	

December 2, 2003
6:33 PM
Tank lift pad .625 wall.r3d



Intrepid Technology and Resources, ...

ITR

PM-2A Tank Lug

December 2, 2003

6:35 PM

Tank lift pad .625 wall.r3d

Company : Intrepid Technology and Resources, Inc.  
 Designer : ITR  
 Job Number :

PM-2A Tank Lug

December 2, 2003  
 6:46 PM  
 Checked By: \_\_\_\_\_

**Joint Coordinates**

Joint Label	X Coordinate (in)	Y Coordinate (in)	Z Coordinate (in)	Joint Temperature (F)	Detach from Diaphragm
N1	0	0	0	0	No
N2	12	0	0	0	No
N3	24	0	0	0	No
N4	36	0	0	0	No
N5	48	0	0	0	No
N6	0	6	0	0	No
N7	12	6	0	0	No
N8	24	6	0	0	No
N9	36	6	0	0	No
N10	48	6	0	0	No
N11	0	12	0	0	No
N12	12	12	0	0	No
N13	24	12	0	0	No
N14	36	12	0	0	No
N15	48	12	0	0	No
N16	0	24	0	0	No
N17	12	24	0	0	No
N18	24	24	0	0	No
N19	36	24	0	0	No
N20	48	24	0	0	No
N21	12	0	.5	0	No
N22	24	0	.5	0	No
N23	36	0	.5	0	No
N24	12	6	.5	0	No
N25	24	6	.5	0	No
N26	36	6	.5	0	No
N27	12	12	.5	0	No
N28	24	12	.5	0	No
N29	36	12	.5	0	No
N30	24	0	3.5	0	No
N31	24	6	3.5	0	No
N32	24	0	6.5	0	No
N33	24	6	6.5	0	No
N34	24	3	.5	0	No
N35	24	3	3.5	0	No
N36	24	3	6.5	0	No
N37	24	0	-3	0	No
N38	24	6	-3	0	No
N39	24	12	-3	0	No
N40	24	24	-3	0	No

Company : Intrepid Technology and Resources, Inc.  
 Designer : ITR  
 Job Number : PM-2A Tank Lug

December 2, 2003  
 6:47 PM  
 Checked By: \_\_\_\_\_

### Plate/Shell Elements

Plate Label	A Joint	B Joint	C Joint	D Joint	Material Set	Thickness (in)	Stress 'R'	Location 'S'	Inactive?
P1	N1	N6	N7	N2	STL	.625	0	0	
P2	N2	N7	N8	N3	STL	.625	0	0	
P3	N3	N8	N9	N4	STL	.625	0	0	
P4	N4	N9	N10	N5	STL	.625	0	0	
P5	N6	N11	N12	N7	STL	.625	0	0	
P6	N7	N12	N13	N8	STL	.625	0	0	
P7	N8	N13	N14	N9	STL	.625	0	0	
P8	N9	N14	N15	N10	STL	.625	0	0	
P9	N11	N16	N17	N12	STL	.625	0	0	
P10	N12	N17	N18	N13	STL	.625	0	0	
P11	N13	N18	N19	N14	STL	.625	0	0	
P12	N14	N19	N20	N15	STL	.625	0	0	
P13	N21	N2	N3	N22	STL	.625	0	0	
P14	N22	N3	N4	N23	STL	.625	0	0	
P15	N23	N4	N9	N26	STL	.625	0	0	
P16	N26	N9	N14	N29	STL	.625	0	0	
P17	N28	N13	N14	N29	STL	.625	0	0	
P18	N27	N12	N13	N28	STL	.625	0	0	
P19	N24	N7	N12	N27	STL	.625	0	0	
P20	N21	N2	N7	N24	STL	.625	0	0	
P21	N21	N22	N25	N24	STL	.625	0	0	
P22	N22	N23	N26	N25	STL	.625	0	0	
P23	N25	N26	N29	N28	STL	.625	0	0	
P24	N24	N25	N28	N27	STL	.625	0	0	
P25	N30	N22	N34	N35	STL	.75	0	0	
P26	N35	N34	N25	N31	STL	.75	0	0	
P27	N32	N30	N35	N36	STL	.75	0	0	
P28	N36	N35	N31	N33	STL	.75	0	0	
P29	N3	N37	N38	N8	STL	1	0	0	
P30	N8	N38	N39	N13	STL	1	0	0	
P31	N13	N39	N40	N18	STL	1	0	0	



Company : Intrepid Technology and Resources, Inc.  
Designer : ITR  
Job Number : PM-2A Tank Lug

December 2, 2003  
6:48 PM  
Checked By: \_\_\_\_\_

***Joint Loads/Enforced Displacements, Category : None. BLC 1 : Lower Half 5/8 wall***

Joint Label	[L]oad,[M]ass,or [D]isplacement	Direction	Magnitude (k, k-in, in, rad, k*s^2/in)
N35	L	Y	-8.36
N35	L	Z	-5.85

Company : Intrepid Technology and Resources, Inc.  
 Designer : ITR  
 Job Number : PM-2A Tank Lug

December 2, 2003  
 6:50 PM  
 Checked By: \_\_\_\_\_

### Reactions, By Combination

LC	Joint Label	X Force (k)	Y Force (k)	Z Force (k)	X Moment (k-in)	Y Moment (k-in)	Z Moment (k-in)
1	N1	2.345	1.038	.838	.103	-5.234	0
1	N6	2.139	-.937	.659	-.284	-4.478	0
1	N11	-.449	-.349	.008	-.038	-.365	0
1	N16	-1.118	1.38	-.064	.022	-.012	0
1	N17	-1.41	5.033	-.044	.279	-.256	0
1	N18	0	25.219	-2.275	-.469	0	0
1	N40	0	-29.187	5.332	0	0	0
1	N19	1.41	5.033	-.044	.279	.256	0
1	N20	1.118	1.38	-.064	.022	.012	0
1	N15	.449	-.349	.008	-.038	.365	0
1	N10	-2.139	-.937	.659	-.284	4.478	0
1	N5	-2.345	1.038	.838	.103	5.234	0
1	Totals:	0	8.36	5.85			
1	COG (in):	X: 24	Y: 3	Z: 3.5			

**Plate/Shell Principal Stresses, By Combination**

LC	Plate Label	Surface [T]op / [B]ottom	Sigma1 (ksi)	Sigma2 (ksi)	Tau Max (ksi)	Angle (radians)	Von Mises (ksi)
1	P1	T	1.336	-.039	.687	-.609	1.356
		B	-.751	-.3	1.124	-.312	2.704
1	P2	T	.349	-1.171	.76	.534	1.38
		B	2.693	.117	1.288	.22	2.637
1	P3	T	.349	-1.171	.76	-.534	1.38
		B	2.693	.117	1.288	-.22	2.637
1	P4	T	1.336	-.039	.687	.609	1.356
		B	-.751	-.3	1.124	.312	2.704
1	P5	T	1.276	.172	.552	-.644	1.2
		B	-.312	-1.54	.614	-.498	1.411
1	P6	T	1.313	-.536	.924	.309	1.648
		B	1.344	.007	.669	.397	1.34
1	P7	T	1.313	-.536	.924	-.309	1.648
		B	1.344	.007	.669	-.397	1.34
1	P8	T	1.276	.172	.552	.644	1.2
		B	-.312	-1.54	.614	.498	1.411
1	P9	T	1.059	.301	.379	.655	.945
		B	-.004	-.238	.117	-.295	.237
1	P10	T	1.857	.12	.869	.199	1.8
		B	.3	.073	.113	.494	.271
1	P11	T	1.857	.12	.869	-.199	1.8
		B	.3	.073	.113	-.494	.271
1	P12	T	1.059	.301	.379	-.655	.945
		B	-.004	-.238	.117	.295	.237
1	P13	T	3.65	-2.333	2.991	-.714	5.223
		B	2.437	-4.826	3.631	.691	6.402
1	P14	T	3.65	-2.333	2.991	.714	5.223
		B	2.437	-4.826	3.631	-.691	6.402
1	P15	T	1.882	.884	.499	.288	1.631
		B	-.346	-2.188	.921	.349	2.037
1	P16	T	1.086	0	.543	-.675	1.086
		B	1.023	-1.576	1.299	.573	2.268
1	P17	T	-.091	-1.004	.457	.626	.962
		B	.985	-.726	.856	.512	1.488
1	P18	T	-.091	-1.004	.457	-.626	.962
		B	.985	-.726	.856	-.512	1.488
1	P19	T	1.023	-1.576	1.299	.573	2.268
		B	1.086	0	.543	-.675	1.086
1	P20	T	-.346	-2.188	.921	.349	2.037
		B	1.882	.884	.499	.288	1.631
1	P21	T	.611	.427	.092	-.069	.543
		B	1.11	-3.084	2.097	-.32	3.765
1	P22	T	.611	.427	.092	.069	.543
		B	1.11	-3.084	2.097	.32	3.765
1	P23	T	.255	-.325	.29	.42	.504
		B	1.527	-2.079	1.803	.343	3.135
1	P24	T	.255	-.325	.29	-.42	.504
		B	1.527	-2.079	1.803	-.343	3.135
1	P25	T	.783	-4.82	2.802	.662	5.256
		B	.783	-4.82	2.802	.662	5.256
1	P26	T	2.349	-.341	1.345	.419	2.537
		B	2.349	-.341	1.345	.419	2.537
1	P27	T	.216	-.836	.526	-.497	.963
		B	.216	-.836	.526	-.497	.963
1	P28	T	.399	-.495	.447	.705	.776
		B	.399	-.495	.447	.705	.776

Company : Intrepid Technology and Resources, Inc.  
 Designer : ITR  
 Job Number : PM-2A Tank Lug

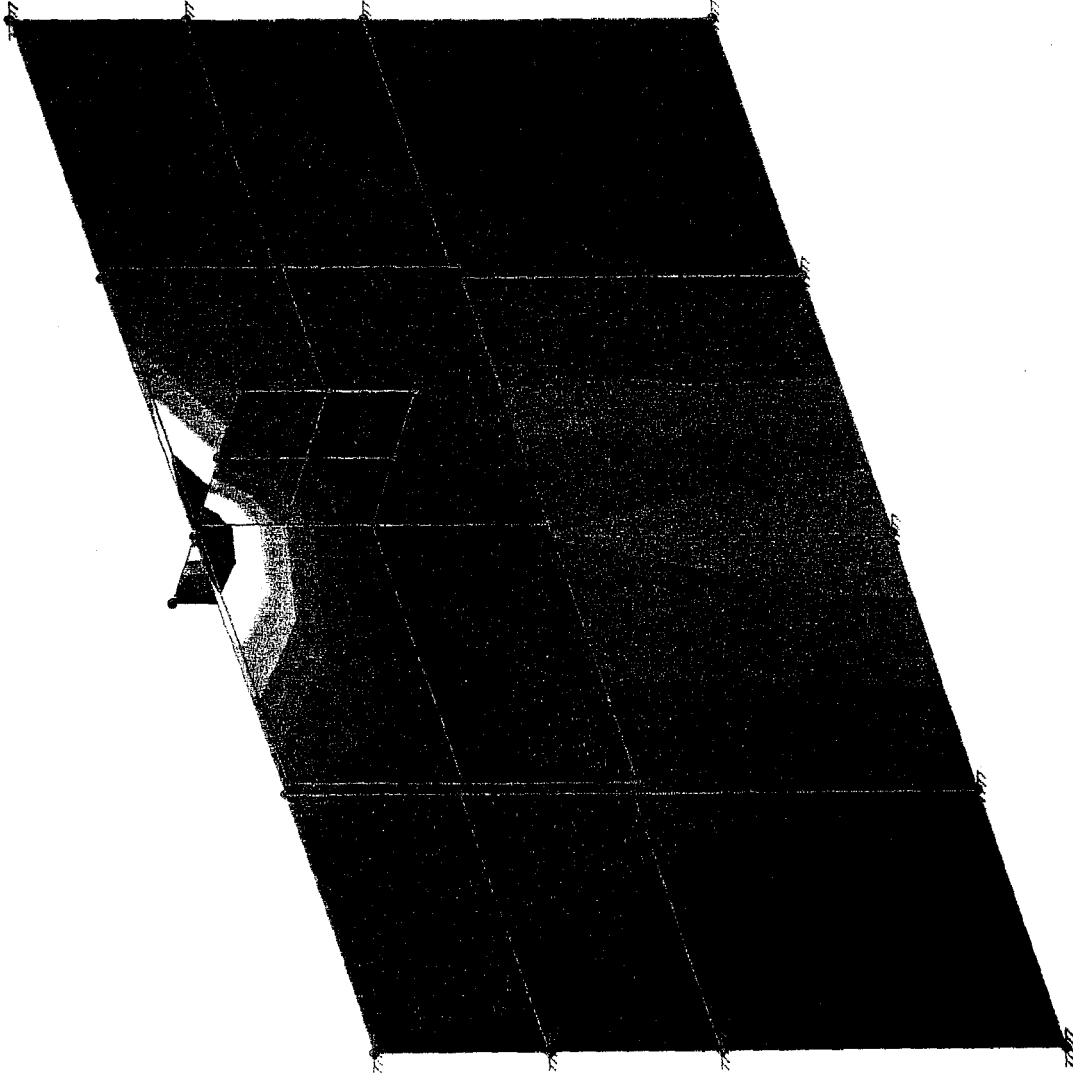
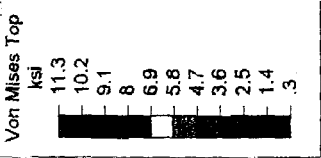
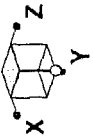
December 2, 2003  
 6:51 PM  
 Checked By: \_\_\_\_\_

***Plate/Shell Principal Stresses, By Combination, (continued)***

LC	Plate Label	Surface [T]op / [B]ottom	Sigma1 (ksi)	Sigma2 (ksi)	Tau Max (ksi)	Angle (radians)	Von Mises (ksi)
1	P29	T	.501	-2.503	1.502	.56	2.787
		B	.501	-2.503	1.502	.56	2.787
1	P30	T	.553	-4.298	2.426	.305	4.6
		B	.553	-4.298	2.426	.305	4.6
1	P31	T	-.024	-4.021	1.999	.28	4.009
		B	-.024	-4.021	1.999	.28	4.009

**Plate/Shell Forces, By Combination**

LC	Plate Label	Qx (k/in)	Qy (k/in)	Mx (k-in/in)	My (k-in/in)	Mxy (k-in/in)	Fx (k/in)	Fy (k/in)	Fxy (k/in)
1	P1	.001	.228	.045	.12	.042	-.173	-.594	-.004
1	P2	.001	-.077	-.009	-.109	.04	.061	.56	.037
1	P3	.001	.077	-.009	-.109	-.04	.061	.56	-.037
1	P4	.001	-.228	.045	.12	-.042	-.173	-.594	.004
1	P5	-.002	.027	.038	.07	.034	-.007	-.119	.004
1	P6	.019	0	.03	-.049	.033	.421	.243	.018
1	P7	.019	0	.03	-.049	-.033	.421	.243	-.018
1	P8	-.002	-.027	.038	.07	-.034	-.007	-.119	-.004
1	P9	-.009	-.007	.026	.026	.014	.236	.114	.094
1	P10	-.006	.013	.054	-.002	.014	.598	.136	.076
1	P11	-.006	-.013	.054	-.002	-.014	.598	.136	-.076
1	P12	-.009	.007	.026	.026	-.014	.236	.114	-.094
1	P13	-.306	.007	.096	.024	.02	-.247	-.088	-2.04
1	P14	-.306	-.007	.096	.024	-.02	-.247	-.088	2.04
1	P15	1.707	.004	.123	.05	.028	-.053	.126	-.1
1	P16	.364	.012	.048	.005	.021	-.047	.214	-.535
1	P17	.337	-.007	-.032	-.012	-.01	.053	-.314	.364
1	P18	.337	.007	-.032	-.012	.01	.053	-.314	-.364
1	P19	-.364	-.012	-.048	-.005	-.021	-.047	.214	-.535
1	P20	-1.707	-.004	-.123	-.05	-.028	-.053	.126	-.1
1	P21	.078	.059	.101	-.003	-.04	-.7	.408	.395
1	P22	-.078	.059	.101	-.003	.04	-.7	.408	-.395
1	P23	-.004	-.049	.047	-.031	.03	-.594	.399	-.424
1	P24	.004	-.049	.047	-.031	-.03	-.594	.399	.424
1	P25	0	0	0	0	0	-2.028	-.1	-2.037
1	P26	0	0	0	0	0	.078	1.428	-.749
1	P27	0	0	0	0	0	-.018	-.448	-.331
1	P28	0	0	0	0	0	.018	-.089	.331
1	P29	0	0	0	0	0	-.346	-1.656	1.351
1	P30	0	0	0	0	0	.116	-3.861	1.389
1	P31	0	0	0	0	0	-.329	-3.716	1.062



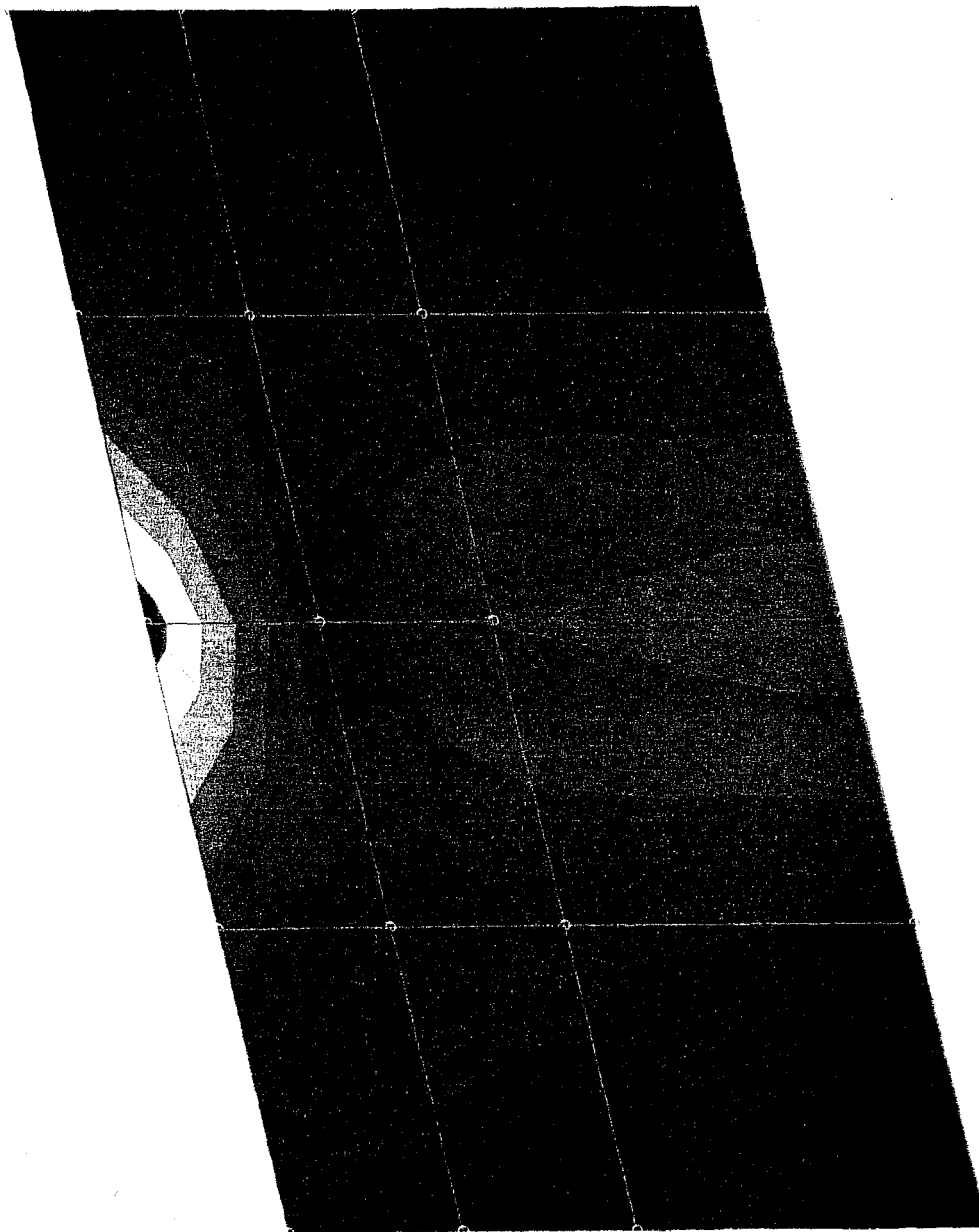
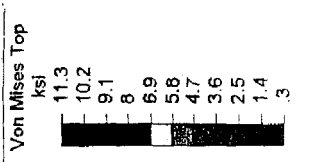
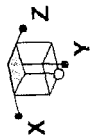
Results for LC 1, Lower Half 5/8 wall
Intrepid Technology and Resources, ...
ITR

PM-2A Tank Lug

December 2, 2003

6:40 PM

Tank lift pad .625 wall.r3d



Results for LC 1, Lower Half 5/8 wall

Intrepid Technology and Resources, ...

ITR

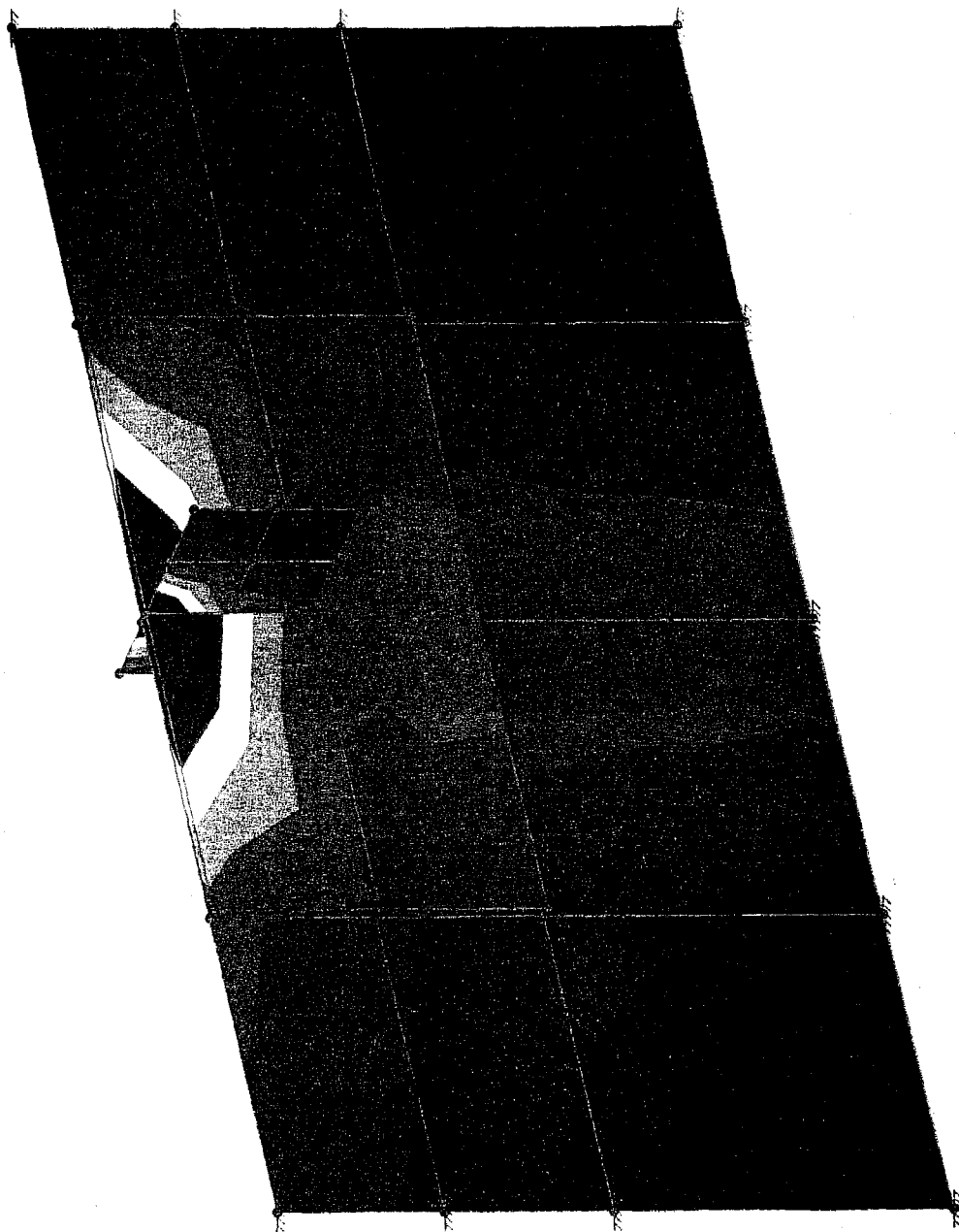
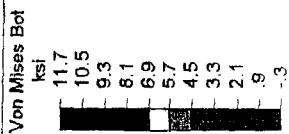
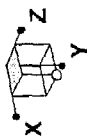
PM-2A Tank Lug

*Tank wall Only*

December 2, 2003

6:41 PM

Tank lift pad .625 wall.r3d



Results for LC 1, Lower Half 5/8 wall

Intrepid Technology and Resources, ...

ITR

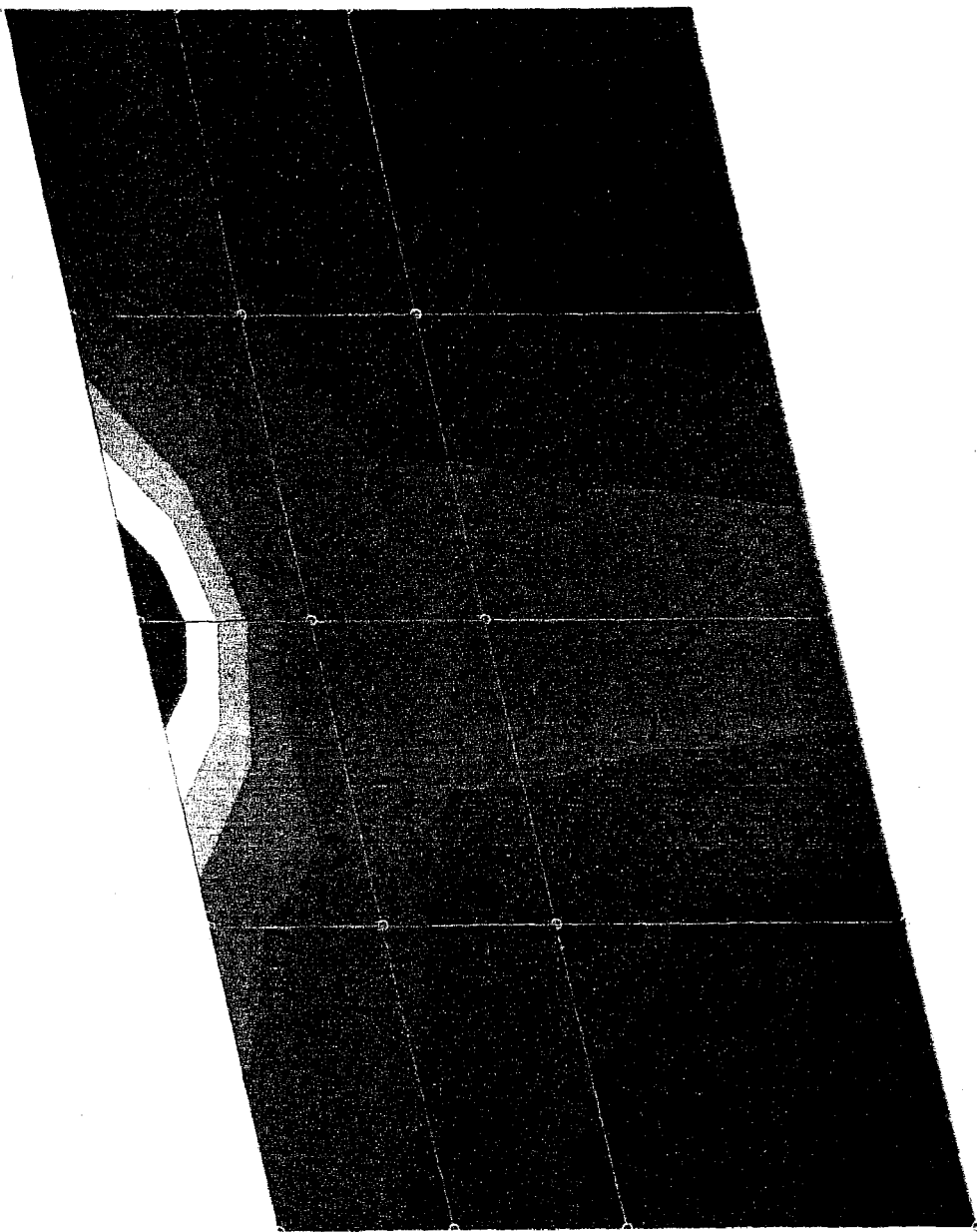
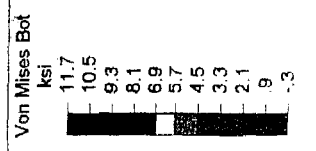
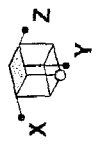
PM-2A Tank Lug

December 2, 2003

6:45 PM

Tank lift pad .625 wall.r3d





Results for LC 1, Lower Half 5/8 wall

Intrepid Technology and Resources, ...

ITR

PM-2A Tank Lug

*Tank Wall Only*

December 2, 2003

6:43 PM

Tank lift pad .625 wall.r3d

## LIFTING LUG ANALYSIS



A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-2A Half Tank Lifting Lug

SHEET NO. 1

OF

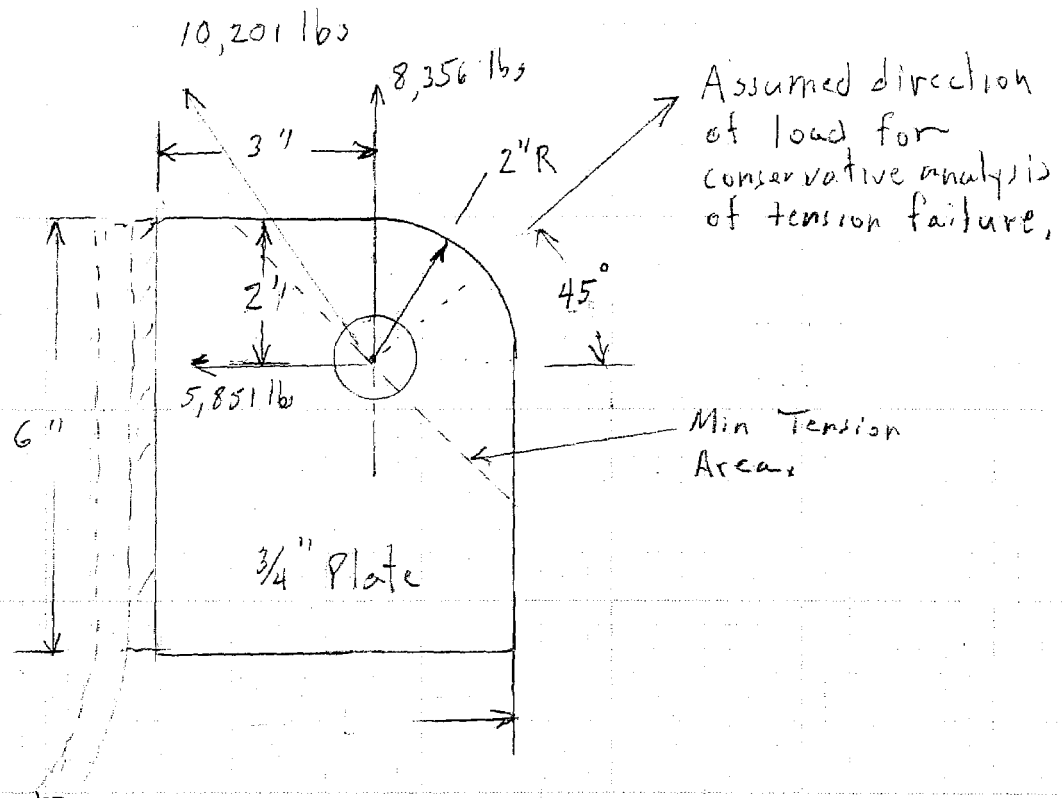
CALCULATED BY Lowell

DATE 12/3/04

CHECKED BY

DATE

SCALE



To simplify the analysis we use the minimum tension area and assume the cable tension load is normal to the area

$$\begin{aligned} \text{Tension Area} &= (\text{plate thickness})(\text{net tension length}) \\ &= (3/4)(2 \times 2 / \cos 45^\circ - 1/6) = 3.35 \text{ in}^2 \end{aligned}$$

$$f_u = P/A = 10,201 / 3.352 = 3,043 \text{ psi or } 3.04 \text{ kips}$$

Factor of Safety based on yield strength

$$S.F. = 36 / 3.04 = 11.84$$

**INTREPID**

Engineering Services, Inc.

A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337JOB PM-2A Half Tank Lifting LugsSHEET NO. 2

OF \_\_\_\_\_

CALCULATED BY LowellDATE 12/3/04

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE \_\_\_\_\_

Bearing Loads on LugsLug will be fabricated from  $\frac{3}{4}$ " steel plate.Material A 36  $F_y = 36$  ksi  $F_u = 58$  ksi (Minimum for A 36)For 1" shackle shackle Bolt  $1\frac{1}{8}$ " diamHole  $1\frac{1}{8} + \frac{1}{16} = 1\frac{5}{16}$ " hole.AISC Manual of Steel Construction Table 1-E  
Page A-6 Ninth EditionMinimum edge distance - Center of hole to edge  
greater than  $1.5d$ , where  $d$  is diameter of pinMinimum edge distance  $= (1.5)(1.125) = 1.69$  inches

(See Notes of Table 1-E)

Edge distance  $2" > 1.69$  inches required and is  
adequate.From Table 1-E for  $F_u = 58$  ksi (Lowest value for  
all materials) and lug thickness of  $\frac{3}{4}$ " and a shackle  
pin diameter of 1" allowable load is 52.2 kips(Table does not have value for  $1\frac{1}{8}$ " pin but use of value  
for 1" pin is conservative)Tension Load  $= 10,201$  lbs  $< 52.2$  lbs allowable  
load on lug is adequate.

1,275

**INTREPID**

Engineering Services, Inc.

A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337JOB PM-2A Half Tank Lifting LugSHEET NO. 3

OF \_\_\_\_\_

CALCULATED BY LowellDATE 12/3/04

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE \_\_\_\_\_

Section J3.9 of the Specification in the Manual of Steel Construction also requires Minimum Edge Distance be greater than value from Table J3.5.

For nominal bolt diameter of  $1\frac{1}{8}$ " inch the minimum edge distance from center of hole to edge is  $1\frac{1}{2}$  inches

$2 > 1\frac{1}{2}$  inches. Edge distance is adequate

Also edge distance shall not be less than

$$L_e \geq 2P/F_u = (2)(10.20)/(58)(0.75) = 0.469 \text{ inches}$$

$2 > 0.469$  Edge distance is adequate.

Also Section J3.7 requires for single bolt in line of force

$$F_{\text{bearing}} < F_p$$

$$F_{\text{bearing}} = \frac{P}{dt} = \frac{10.20}{(1.125)(0.75)} = 12.09 \text{ ksi}$$

$$F_p = L_e F_u / 2d = (2.0)(58) / (2)(1.125) = 51.6 \text{ ksi}$$

Where  $L_e = 2$  is the distance from the free edge to center of hole.

Also  $F_p$  cannot exceed

$$1.2 F_u = (1.2)(58) = 69.6$$

$51.6 < 69.6$  therefore the limit is 51.6 ksi

**INTREPID**

Engineering Services, Inc.

A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337JOB PM-2A Half Tank Lifting LugSHEET NO. 4

OF

CALCULATED BY LowellDATE 12/3/04

CHECKED BY

DATE

SCALE

Pin bearing stress  $12.09 < 51.6$

$$\text{Factor of safety} = \frac{51.6}{12.09} = 4.27$$

Bearing of  $1\frac{1}{8}$ " diam bolt of 1 inch shackle  
is acceptable

Lug with  $\frac{3}{4}$ " plate and  $1\frac{3}{16}$ " hole and 2"  
radius to edge of plate is adequate with  
large margin.



A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-2A Half Tank Lifting Lug

SHEET NO. 5

OF

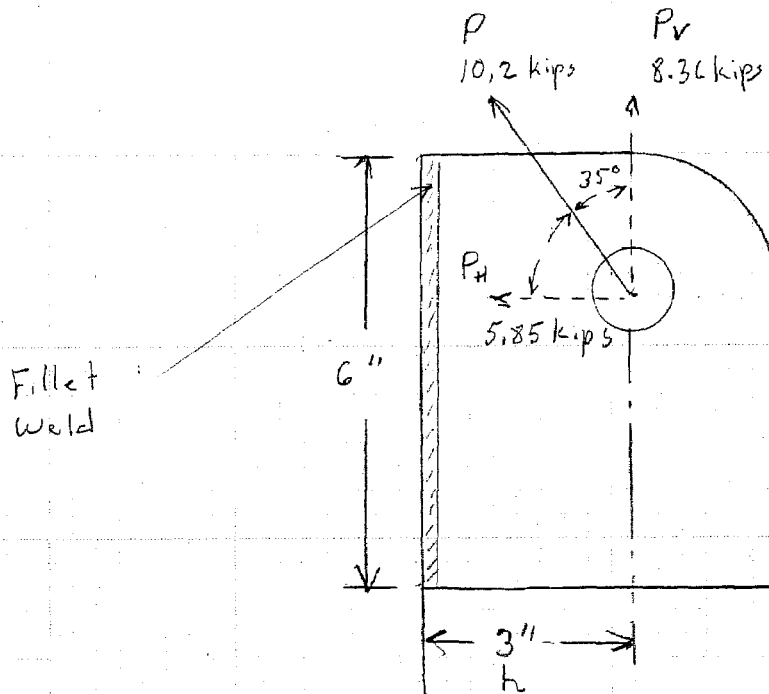
CALCULATED BY Lowell

DATE 12/3/03

CHECKED BY

DATE

SCALE



Tension in the cable  $P = 10.20$  kips

Horizontal component  $P_H = (10.20)(\sin 35^\circ) = 5.85$  kips

Vertical component  $P_V = (10.20)(\cos 35^\circ) = 8.36$  kips.

Vertical Component produces moment at base of  
lug.  $M_{\text{lug}} = P_V h = (8.36)(3) = 25.08$  kip-in

There is a fillet on each side of the lug so the moment  
on one fillet is  $M = 25.08/2 = 12.54$  kip inches.

**INTREPID**

Engineering Services, Inc.

A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337JOB PM-2A Half Tank Lifting LugSHEET NO. 6

OF

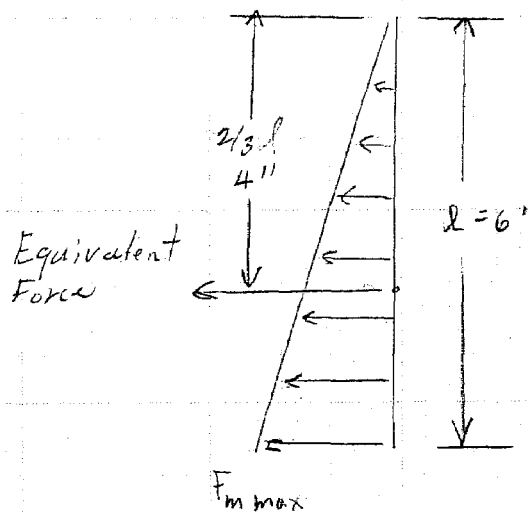
CALCULATED BY LowellDATE 12/3/03

CHECKED BY

DATE

SCALE

The stress resisting the moment is approximated as a linear distribution.



Where  $F_m$  units are kips per inch of weld length.

The moment resisted by the distributed stress

$$M = (\text{Total Force})(\text{Distance to center of force})$$

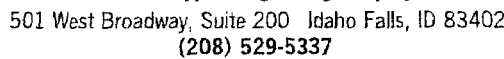
$$= \left(\frac{1}{2} F_{m \max} l\right) \left(\frac{2}{3} l\right) = \frac{F_{m \max} l^2}{3}$$

Set equal to the moment from sheet 5 and solve for  $F_{m \max}$

$$\frac{F_{m \max} l^2}{2} = \frac{F_{m \max} 6^2}{3} = 12.54 \text{ kip inches}$$

$$F_{m \max} = \frac{(3)(12.54)}{6^2} = 1.05 \text{ kips per inch of weld}$$





SCALE \_\_\_\_\_

View AA.

Half-Tank wall

Lug

Fillet

$\frac{1}{2}$  plate



A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-2A Half Tank Lifting Lugs

SHEET NO. 8

OF

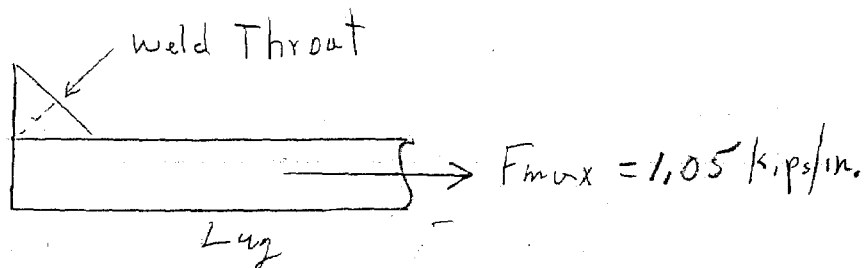
CALCULATED BY Lowell

DATE 12/3/03

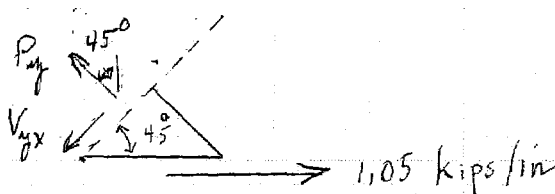
CHECKED BY

DATE

SCALE



Forces on weld throat at location of max stress.



$\Sigma$  Forces  $\rightarrow$

$$1.05 = P_y \cos 45 + V_{yx} \cos 45 \quad (1)$$

$\Sigma$  Forces  $\uparrow$

$$0 = P_y \cos 45 - V_{yx} \cos 45 \quad (2)$$

$$2 P_y \cos 45 = 1.05$$

$$P_y = 0.742 \text{ kips per inch}$$

From eq.(2)

$$V_{yx} = P_y = 0.742 \text{ kips per inch.}$$

From Table I 2.4 of the Specification in the Manual of Steel Construction, the minimum weld size for  $3/4$  inch plate is  $1/4$  inch. To obtain a factor of safety of at least 3 a larger weld size of  $1/2$  inch is used

**INTREPID**

Engineering Services, Inc.

A New Type of Engineering Company

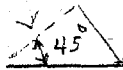
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337JOB PM-2A Half Tank Lifting LugsSHEET NO. 9OF 9CALCULATED BY LowellDATE 12/3/03

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE \_\_\_\_\_

The area of the throat for 1 inch of length,  
 $.5 \cos 45^\circ$



$$A_t = (.5 \cos 45^\circ)(1 \text{ inch of length}) = 0.354 \text{ in}^2$$

$$\sigma_y = P_y / A_t = 0.742 / 0.354 = 2.096$$

$$\tau_{yx} = V_{yx} / A_t = 0.742 / 0.354 = 2.096$$

$$\tau_{yz} = V / A_t = 0.697 / 0.354 = 1.969, \text{ } V \text{ from page 7}$$

The component principal stresses are determined from the solution of the cubic equation. See attached page from ASTM Handbook Volume II Failure Analysis and Prevention

The coefficients for the cubic equation

$$I_1 = \sigma_x + \sigma_y + \sigma_z = 0 + 2.096 + 0 = 2.096$$

$$I_2 = \sigma_x \sigma_y + \sigma_y \sigma_z + \sigma_z \sigma_x - \tau_{xy}^2 - \tau_{yz}^2 - \tau_{zx}^2$$

$$= 0 + 0 + 0 - 2.096^2 - 0 - 1.969^2 = -8.270$$

$$I_3 = \sigma_x \sigma_y \sigma_z + 2 \tau_{xy} \tau_{yz} \tau_{zx} - \sigma_x \tau_{yz}^2 - \sigma_y \tau_{zx}^2 - \sigma_z \tau_{xy}^2$$

$$= 0 + 0 - 0 - 0 - 0 = 0$$



A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-2A Half Tank Lifting Legs

SHEET NO. 10

OF 8

CALCULATED BY LOW

DATE 12/3/05

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE \_\_\_\_\_

Cubic Equation

$$\sigma^3 - I_1\sigma^2 + I_2\sigma - I_3 = 0$$

$$\sigma^3 - 2.096\sigma^2 - 8.270 - 0 = 0$$

Solution for cubic equation from

[www.1728.com/cubic.htm](http://www.1728.com/cubic.htm) (Sheet Attached)

$$\sigma_1 = 4.109 \text{ ksi}$$

$$\sigma_2 = -2.013 \text{ ksi}$$

$$\sigma_3 = 0$$

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{4.109 + 2.013}{2} = 3.06 \text{ ksi}$$

Allowable Stress from Table J2.5 of the Specification  
in the AISC Manual of Steel Construction

$$\tau_{max \text{ allowable}} = 0.3 F_u$$

For weld filler metal  $F_u = 70 \text{ ksi}$

$$\tau_{max \text{ allowable}} = (0.3)(70) = 21 \text{ ksi}$$

$\tau_{max} = 3.06 < 21 \text{ ksi}$  allowable and  $1/2"$  filled,  
weld is adequate.

$$\text{Factor of Safety } 21/3.06 = 6.86$$

## 8. COMBINED STRESS

Under certain circumstances of loading a body is subjected to a combination of tensile, compressive, and/or shear stresses. For example, a shaft which is simultaneously bent and twisted is subjected to combined stresses, namely, longitudinal tension and compression and torsional shear. For the purposes of analysis it is convenient to reduce such systems of combined stresses to a basic system of stress coordinates known as principal stresses. These stresses act on axes which differ in general from the axes along which the applied stresses are acting and represent the maximum and minimum values of the normal stresses for the particular point considered.

**Determination of Principal Stresses.** The expressions for the principal stresses in terms of the stresses along the  $x$  and  $y$  axes are

$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \quad (1)$$

$$\sigma_2 = \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \quad (2)$$

$$\tau_1 = \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \quad (3)$$

where  $\sigma_1$ ,  $\sigma_2$ , and  $\tau_1$  are the principal stress components and  $\sigma_x$ ,  $\sigma_y$ , and  $\tau_{xy}$  the calculated stress components, all of which are determined at any particular point (Fig. 1).

**Graphical Method of Principal Stress Determination—Mohr's Circle.** Let the axes  $x$  and  $y$  be chosen to represent the directions of the applied normal and shearing stresses, respectively (Fig. 2). Lay off to suitable scale distances  $OA = \sigma_y$ ,  $OB = \sigma_x$ , and  $BC = AD = \tau_{xy}$ . With point  $E$  as a center construct the circle  $DFC$ . Then  $OF$  and  $OG$  are the principal stresses  $\sigma_1$  and  $\sigma_2$  respectively, and  $EC$  the maximum shear stress  $\tau_1$ . The inverse

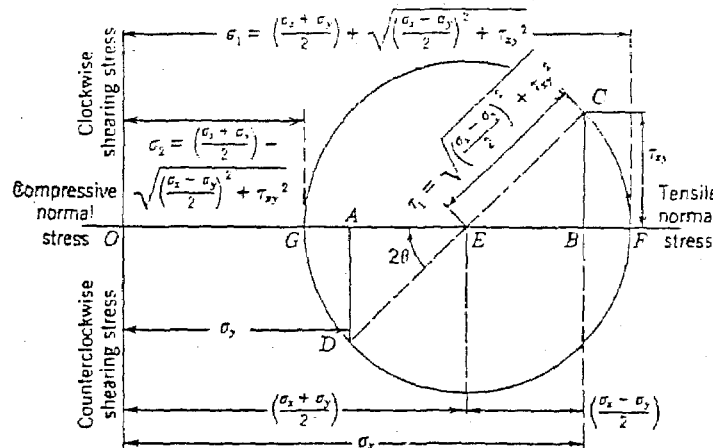


FIG. 2. Mohr's circle used for the determination of the principal stresses. (Reproduced with modification by permission from Joseph Marin, *op. cit.*)

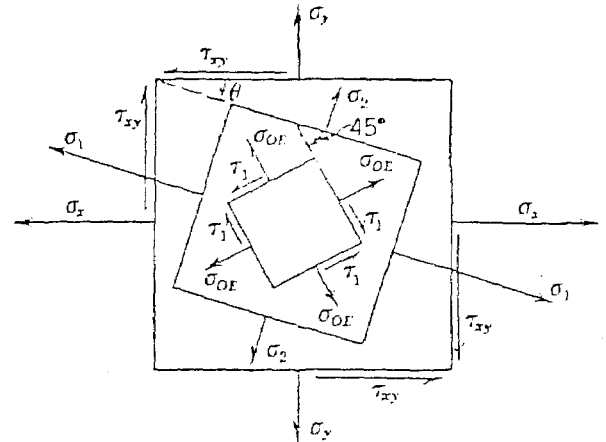


FIG. 1. Diagram showing relative orientation of stresses. (Reproduced with modification by permission from *Mechanical Properties of Materials and Design*, by Joseph Marin, McGraw-Hill Book Co.)

also holds; that is, given the principal stresses,  $\sigma_x$  and  $\sigma_y$  can be determined on any plane passing through the point.

**Stress-strain Relations.** The linear relation between components of stress and strain is known as *Hooke's law*. This relation for the two-dimensional case can be expressed as

$$\epsilon_x = \frac{1}{E} (\sigma_x - \nu \sigma_y) \quad (4)$$

$$\epsilon_y = \frac{1}{E} (\sigma_y - \nu \sigma_x) \quad (5)$$

$$\gamma_{xy} = \frac{1}{G} \tau_{xy} \quad (6)$$

where  $\sigma_x$ ,  $\sigma_y$ , and  $\tau_{xy}$  are the stress components of a particular point,  $\nu$  = Poisson's ratio,  $E$  = modulus of elasticity,  $G$  = modulus of rigidity, and  $\epsilon_x$ ,  $\epsilon_y$ , and  $\gamma_{xy}$  = strain components.

It was noted that Eq 15 is the equation of a circle with axes  $\sigma$  and  $\tau$  and centered on the  $\sigma$  axis with:

$$\text{center} = \left( \frac{\sigma_x + \sigma_y}{2} \right) \quad (\text{Eq 16})$$

and radius,  $R$ , given by:

$$R^2 = \left( \frac{\sigma_x + \sigma_y}{2} \right)^2 + \tau_{xy}^2 \quad (\text{Eq 17})$$

The result is that stress transformations can be performed by using the geometric principles of a circle. For example, if stresses are known at a point, they are plotted on a figure that has horizontal axis  $\sigma$  and vertical axis  $\tau$  so that  $(\sigma_x, \tau_{xy})$  is the coordinate point at horizontal position  $\sigma_x$  and vertical position  $\tau_{xy}$  and so that  $(\sigma_y, \tau_{yx})$  is the coordinate that corresponds to  $\sigma_y$  and  $\tau_{yx}$ . Since the center of the circle is on the  $\sigma$  axis, this can be easily found by Eq 16. The radius of the circle is given by Eq 17. From this, the entire circle can be drawn. This is illustrated by the schematic Mohr's circle in Fig. 5.

Then for a rotation of axes by  $\theta$  in the stress element, the position on the Mohr's circle must go through a rotation of  $2\theta$  in the same direction but around the circumference of the circle. Every point on the circle corresponds to a possible stress pair. Note that a rotation of  $180^\circ$  of the circle corresponds to a rotation of the stress element by  $90^\circ$  so that  $\sigma_x$  is transformed to  $\sigma_y$  as shown in Fig. 5.

**Principal Stresses.** The purpose of a stress transformation is mainly to find the stresses that can be used in a failure criterion. These would be either the largest magnitude stresses in any direction or the magnitude of stresses on a weak plane. For the former, the extreme stresses can be found by taking Eq 11 and applying the calculus principle  $d\sigma_x/d\theta = 0$ . That is, principal stresses are normal (perpendicular) stresses on planes for which the shear stresses are zero. The values of principal stresses are given by:

$$\sigma_1, \sigma_2 = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left( \frac{\sigma_x - \sigma_y}{2} \right)^2 + \tau_{xy}^2} \quad (\text{Eq 18})$$

where the positive radical gives a maximum stress labeled  $\sigma_1$  and the negative radical a minimum stress  $\sigma_2$ . Notice that the positions of the extreme stresses are the points on the Mohr's circle where the circle crosses the  $\sigma$  axis (horizontal axis) (Fig. 5).

The right side of the circle corresponds to a maximum normal stress and the left side to a minimum stress. These stresses are called principal stresses and are often labeled  $\sigma_1$  and  $\sigma_2$ . Notice that the extremal stress given by Eq 18 is equivalent to taking the center  $\pm$  the radius of the Mohr's circle. In this way the extreme values of stresses can be easily found by simply using the Mohr's circle.

The maximum shear stress,  $\tau_{\max}$ , can also be found by taking  $\tau_{x'y'}$  from Eq 12 and using the calculus principal  $d\tau_{x'y'}/d\theta = 0$ . This results in:

$$\tau_{\max} = \pm \sqrt{\left( \frac{\sigma_x - \sigma_y}{2} \right)^2 + \tau_{xy}^2} \quad (\text{Eq 19})$$

The value of  $\tau_{\max}$  is the radius of the Mohr's circle, and the corresponding points on the Mohr's circle are at the top and bottom of the circle as shown in Fig. 5. The maximum shear stress could also be written as:

$$\tau_{\max} = \frac{\sigma_1 - \sigma_2}{2} \quad (\text{Eq 20})$$

Note that the maximum normal stresses are defined at a position where the shear stresses are zero. A plane with zero shear stress is defined as a principal stress plane, that is, a plane having only normal stresses. This can be extended to three dimensions. Given a symmetric stress tensor as defined previously, a transformation is desired to a plane that results in the stress tensor having only normal stress components; all shear components are zero. This would be given by:

$$\begin{pmatrix} \sigma_1 & 0 & 0 \\ 0 & \sigma_2 & 0 \\ 0 & 0 & \sigma_3 \end{pmatrix}$$

The transformation results in a cubic equation in  $\sigma$  given by:

$$\sigma^3 - I_1\sigma^2 + I_2\sigma - I_3 = 0 \quad (\text{Eq 21})$$

where

$$\begin{aligned} I_1 &= \sigma_x + \sigma_y + \sigma_z \\ I_2 &= \sigma_x\sigma_y + \sigma_y\sigma_z + \sigma_z\sigma_x - \tau_{xy}^2 - \tau_{yz}^2 - \tau_{zx}^2 \\ I_3 &= \sigma_x\sigma_y\sigma_z + 2\tau_{xy}\tau_{yz}\tau_{zx} - \sigma_x\tau_{yz}^2 \\ &\quad - \sigma_y\tau_{zx}^2 - \sigma_z\tau_{xy}^2 \end{aligned} \quad (\text{Eq 22})$$

The values of the coefficients,  $I_1$ ,  $I_2$ , and  $I_3$  are called the stress invariants and are independent of the coordinate system used to describe the stress state. However, here they are used to solve the stress cubic given in Eq 21 so that three principal stresses result:  $\sigma_1$ ,  $\sigma_2$ , and  $\sigma_3$ . In three dimensions, the maximum shear stresses can be found in the same way to the 2D stresses, that is as one-half the difference of any two principal stresses.

If stresses  $\sigma_1$ ,  $\sigma_2$ , and  $\sigma_3$  are ordered from maximum to minimum, then the absolute maximum shear stress in three dimensions is:

$$\tau_{\max(\text{abs})} = \frac{\sigma_1 - \sigma_3}{2} \quad (\text{Eq 23})$$

The transformation of stress in three dimensions can be made with equations like Eq 14. For this transformation, a circle like the Mohr's circle

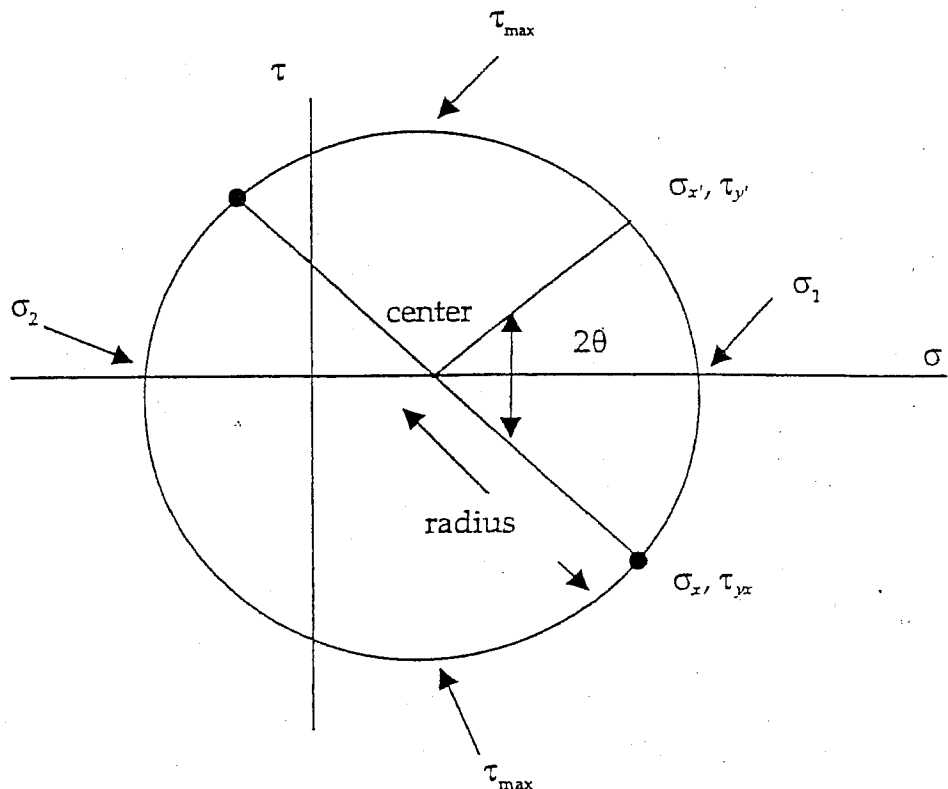


Fig. 5 Mohr's circle for two-dimensional stress transformation

---

## Cubic Equation Calculator

---

Input **MUST** have the format:  $AX^3 + BX^2 + CX + D = 0$

EXAMPLE: If you have the equation:  $2X^3 - 4X^2 - 22X + 24 = 0$

then you would input: A= 2 B= -4 C= -22 D=24

Click **E N T E R** and your answers should be 4, -3 and 1

A=  B=  C=  D=

**E N T E R**

$X_1 =$

$X_2 =$

$X_3 =$

To see the method for solving cubic equations, click [HERE](#)



Copyright © 2000 1728 Software Systems



EDF Title: PM-2A Half Tank Cover

Project No.: 2000-096

Project Title: PM-2A Tanks and Burn Pits RD/RAWP

## Problem Statement:

A cover is to be designed for the PM-2A half tank to prevent the debris in the tank from being scattered around the work site but allow access to the tank to remove the sludge and clean the tank. The access opening is to be five feet wide and allow access for the full width of the tank. The opening is to be designed so that it will move along the tank to sequentially provide access for removing the sludge and cleaning the tank over the full length of the tank.

## Summary of Conclusions:

The designed cover is shown on the attached sketches and on the Drawing, Half Tank Cover, included with the design drawings for the project. The design utilizes a 20 mil plastic cover fixed at each end with a cart in between with reels spaced to provide a 5 feet opening between them. The design is for one reel to wind up the cover from one end of the tank and the other reel to unwind the cover from the other end with the cart and 5 foot space traveling along the tank.

## Review and Approval Signatures:

	R/A	Printed Name	Signature	Date
Prepared by:		Herbert L Magleby	<i>Herbert L Magleby</i>	7/10/07
Checked by:		KEVIN SHABER	<i>Kevin Shaber</i>	10/20/03
Approval:		GARY MECHAM	<i>Gary Mecham</i>	10/21/03

## Distribution:

Professional Engineer's Stamp (if required)





EDF Title: PM-2A Half Tank Cover		EDF- 096 - 013	
Project No.: 2000-096		Rev No.:	
Project Title: PM-2A Tanks and Burn Pits RD/RAWP		Page 2 of 2	
Prepared by:	Date:	Checked by:	Date:

### Problem Statement:

A cover is to be designed for the PM-2A half tank to prevent the debris in the tank from being scattered around the work site but allow access to the tank to remove the sludge and clean the tank. The access opening is to be five feet wide and allow access for the full width of the tank. The opening is to be designed so that it will move along the tank to sequentially provide access for removing the sludge and cleaning the tank over the full length of the tank.

### Assumptions:

A 20 mil plastic cover that overlaps the tank sides at least 9 inches will provide adequate containment. The radiation levels will be low enough that personnel will have access to install the cover system and to operate the cover system.

### References:

### Calculations / Analysis:

The design utilizes a 20 mil plastic cover fixed at each end with a cart in between with reels spaced to provide a 5 feet opening between them. The design is for one reel to wind up one end of the cover and the other to unwind the other end with the cart and the 5 foot space traveling along the tank. The cart frame is made with 6 inch light weight channels and has two foot wide platforms on each end of the five foot opening. The platforms use a 1/4 inch thick aluminum cover to provide torsional rigidity. The platforms are designed to support a 200 lb man standing at their centers. Calculations are attached.

Commercially available swimming pool cover reels are used to wind and unwind the cover. The cart is designed with polyurethane flange wheels that support the cart and roll along the half tank edge. Each corner of the cart has a set of two wheels spaced about 1 foot apart to accommodate any irregularities in the half tank edges. The wheels are flanged on one side and the flanges will be positioned on the outside of the tank to keep the cart correctly positioned over the half tank.

The weight of the cart without the plastic cover is about 500 lbs with only about 62.5 lbs per wheel giving confidence that even a deteriorated tank can easily support the cart. Also, the feature of the two closely spaced wheels at each corner allows for one wheel to lose support if the tank has deteriorated and the other wheel to pick up the load. When the first wheel reaches solid support it will carry the load while the second travels over the deteriorated area.

The plastic cover is to be fixed at each end of the half tank. The structure to support and fix the plastic cover at the ends of the tank is shown on EDF 096 – 014.

### ATTACHMENTS

Design Sketches  
Design Calculations  
Vendor Data

## **DESIGN SKETCHES**



**INTREPID**

Engineering Services, Inc.

A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

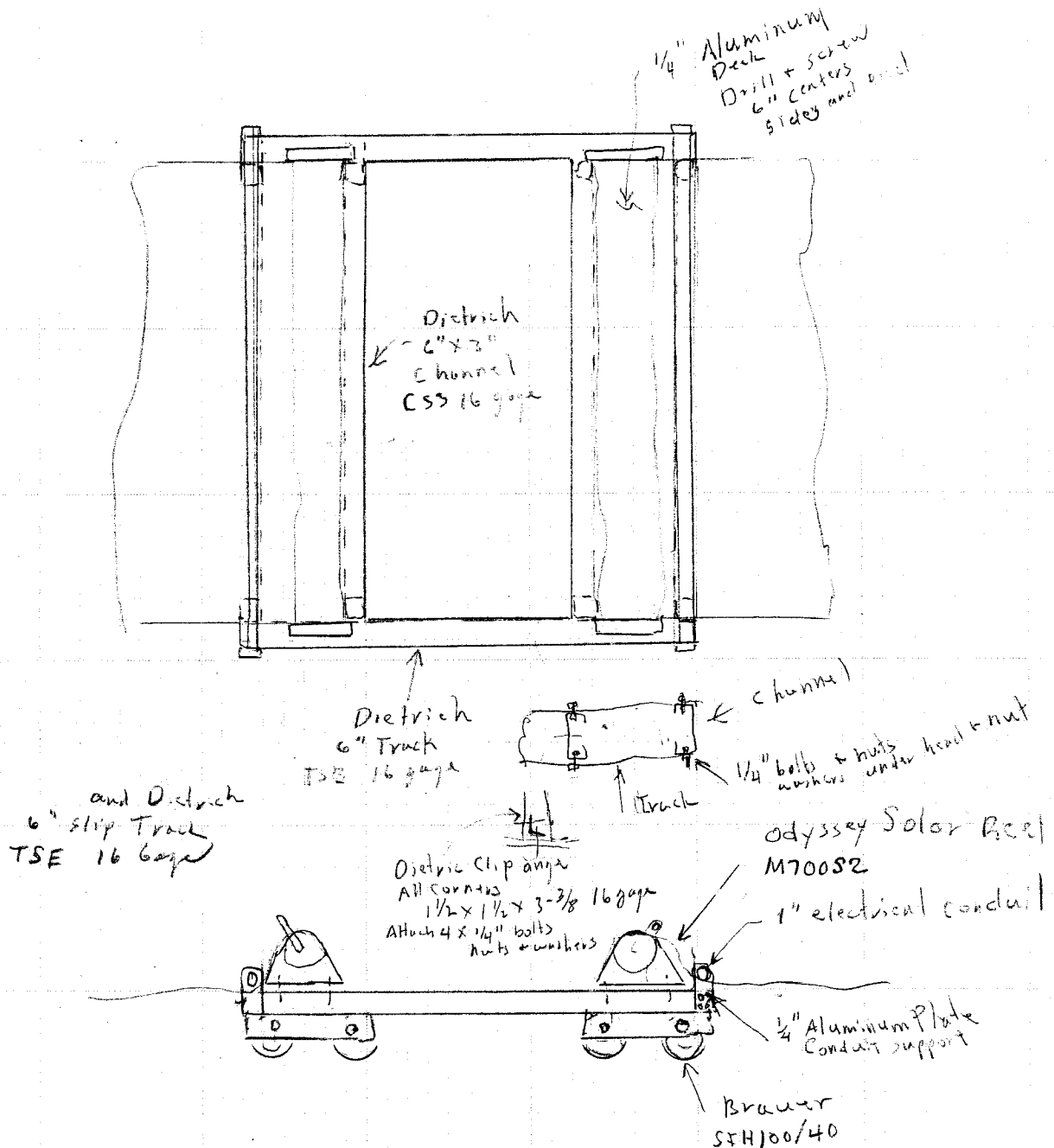
JOB PM-2A Tank Decon Cover

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY \_\_\_\_\_ DATE \_\_\_\_\_

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_





A New Type of Engineering Company  
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

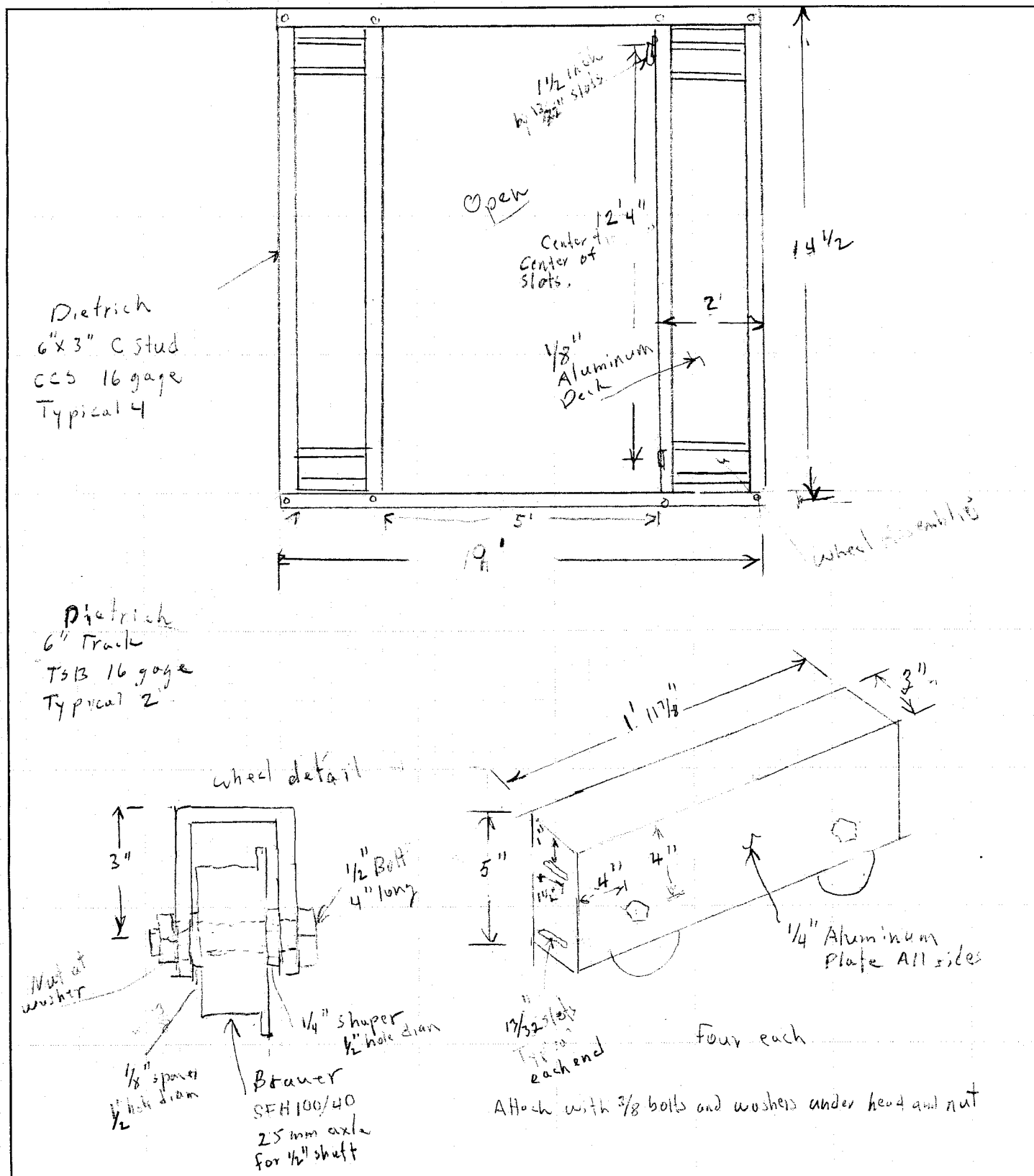
JOB PM-2A Decon Cover

SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY \_\_\_\_\_ DATE \_\_\_\_\_

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_



## **DESIGN CALCULATIONS**



A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM 2A Tank Cover

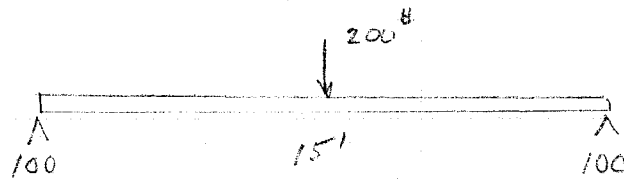
SHEET NO. \_\_\_\_\_ OF \_\_\_\_\_

CALCULATED BY \_\_\_\_\_ DATE \_\_\_\_\_

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

For 200<sup>lb</sup> at center of 15' beam



$$M = 100 \times 7.5 \times 12 = 9.0 \times 10^3 \text{ in-lb}$$

$$\sigma = \frac{1}{2} \sigma_y = 18,000 \text{ psi Allowable stress (Conservative limit)}$$

$$\sigma = \frac{MC}{I} = \frac{M}{S}$$

$$S = \frac{M}{\sigma} = \frac{9 \times 10^3}{18 \times 10^3} = 0.500$$

$$\frac{11.16}{16} = 11^3$$

Dietric 6x3" C stud 16 gage  $S = 1.509 \text{ in}^3$  is more than adequate

Dietric 6x3" C stud 16 gage

$$S_y = 1.509 \text{ in}^3 \text{ weight per foot } 2.516$$

Total weight of cart

$$6 \times 3 \text{ CSTUDS } 4 \times 14.5 \times 2.516 + 2 \times 9 \times 1.557 = 17.5 \text{ lb}$$

$$\frac{1}{4}'' \text{ Aluminum Deck } 2 \times 2 \times 14.5 \times \frac{0.175}{12} \times 165 = 100$$

$$\text{wheels } 8 \times 2.7 \text{ kg} \times 22 \text{ lb/kg} = 50$$

$$\text{Reels } 2 \times 75 = 150$$

$$\text{Miscellaneous } 25 \text{ lb.} \quad \underline{25} \quad 500 \text{ lbs}$$

Plus weight of one cover

## **VENDOR DATA**

**Odyssey Solar Reels**

M400	Deluxe Residential 12' - 20' w/casters	504.00
M700S2	Commercial Reel 21' - 26'	870.00
620	Bearing Race (M700S2)	27.33
OD101	Extra Strap Kit	58.91

**Above Ground Reels**

M818	Above Ground Reel 12' - 18'	286.50
M824	Above Ground Reel 19'-24'	330.00
OD101	Extra Strap Kit	58.91

**Above Ground Liners****10 Mil, Splasher Pool**

LI1236	12' x 36"	83.12
--------	-----------	-------

**20 Mil, Above Ground**

LI1248HD	12' x 48"	130.77
LI1548HD	15' x 48"	173.64
LI1848HD	18' x 48"	257.10
LI2148HD	21' x 48"	281.02
LI2448HD	24' x 48"	301.56
LI2748HD	27' x 48"	421.96
LI15X30X48HD	15' x 30' x 48" Oval	348.75
LI16X32X48HD	16' x 32' x 48" Oval	426.78
LI2448X72HDEXP24'	Expandable Liner	181.66

**Plastimaid Vinyl Repair Kits**

5870	Patch Glue 12oz.	23.94
5875	Deluxe Repair Kit	17.31
5878	Patch Kit - 4oz.	16.65
5882	Patch Kit - 2oz.	8.61

**Aquality Vinyl Patch Kit**

AQ10012	Patch-N-Seal Kit	13.71
---------	------------------	-------

**Above Ground Liner Coping**

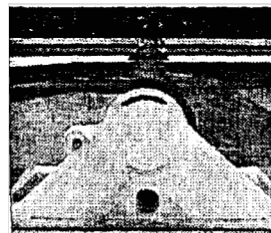
AGPC	Liner Coping 53" Long	3.79
------	-----------------------	------



And Water Tube  
up 2



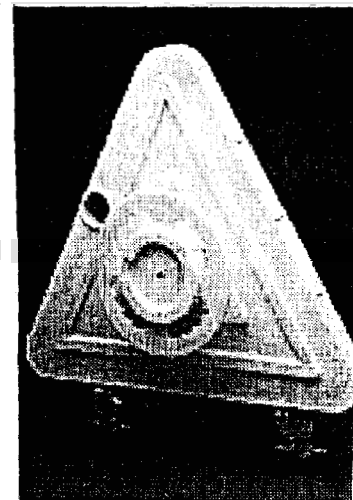
r Cover Step 2



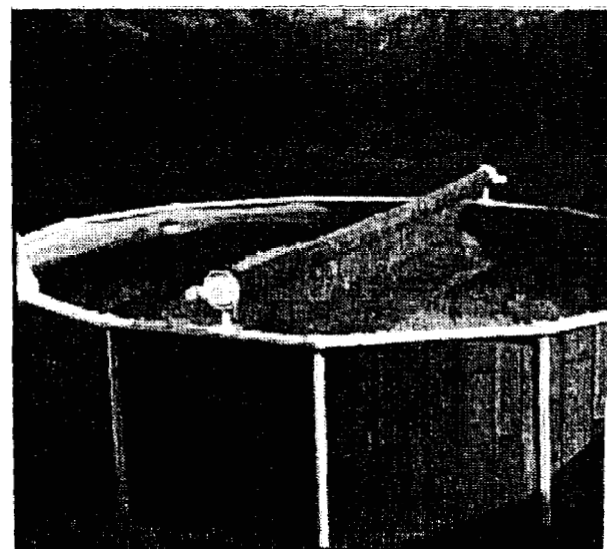
M400 Deluxe Residential



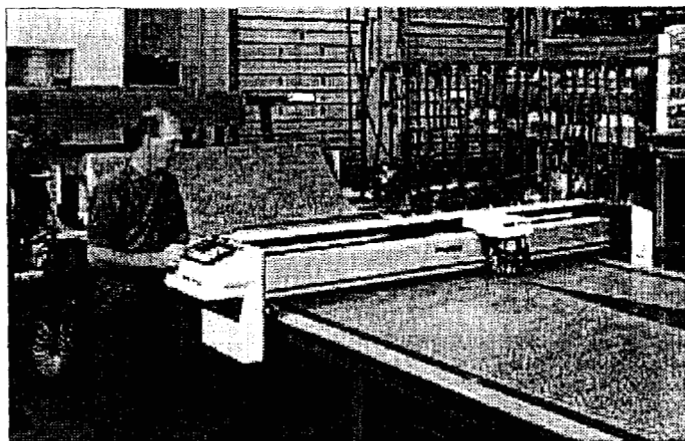
M400 Deluxe Residential



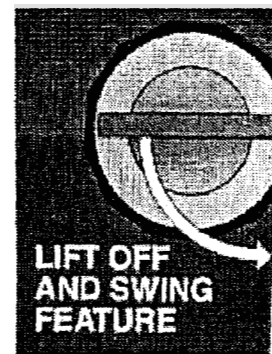
M700S2  
Commercial Reel



M818 & M824  
Above Ground Reel



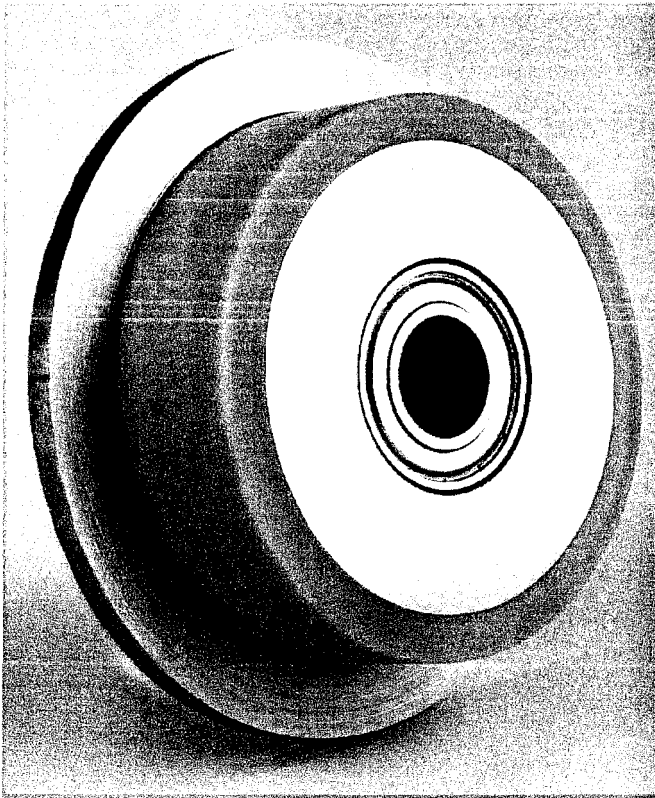
M818 & M824  
Above Ground Reel



M 818



# Polyurethane Tyred Single-flanged Rail Wheels



Standard wheel features flanges with a 5° angle and a 'flat tread' (ie tread parallel to the wheel axis) for running on flat top rail. Polyurethane is resilient, durable material, resistant to abrasion and to many common chemicals. Polyurethane tyred wheels are capable of carrying heavy loads and of transmitting driving forces

**MATERIAL:** Wheel Centre - Steel to BS970: Part 1: 1983: 080 M40  
Tyre - Polyester Based Polymer of 92° ± 3° A Shore Hardness

**OPERATING TEMPERATURE RANGE:**  
-20°C to + 60°C (115°C for limited use)

PLEASE SPECIFY IF OPERATING IN HIGH HUMIDITY.  
**Anti-hydrolysis polyurethane is recommended for use in an operating environment of high humidity.**

**Polyurethane to the above hardness used on these wheels is Vulkollan, a high quality material that provides superior performance in most applications.**

**Should the mechanical properties of Vulkollan be inappropriate for the application, alternative grades of Polyurethane can be produced to meet the requirements. Polyurethane can be bonded onto most metal centres including aluminium, titanium, stainless steel and various ferrous and non-ferrous alloys.**

The 'Maximum Load Rating' given for each wheel assumes the full tread width is in contact with the rail. In practice full contact with the rail across the tread width is rarely achieved due to:-

- a) Flange to rail clearance
- b) Wheel Overhang
- c) Rail Corner Radii

For calculation of the 'Maximum Allowable Load' see 'Design Data' Para 6.1

In addition the 'Maximum Load Rating' given for each wheel is for operation under ideal conditions.

Load factors must be applied according to the anticipated working conditions - see 'Design Data' Para 4.1

Alternative Bore/Bearing diameters and alternative bearing types (i.e) bronze brushes, self lubricating brushes, etc.) are available to order - see page 17-18.

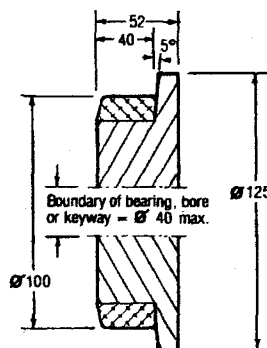
For technical information covering load factors, inertial and rolling resistance, chemical resistance, coefficients of friction between wheel and track and keyway dimensions, see 'Data Design' index on page 12.

**Wheel type:**  
**SFH100/40**  
See table for full part number

**Maximum load rating: 500kg**

See 'Design Data' paras 4.1 and 6.1 for 'Maximum Allowable Load'.

**Approximate weight: 2.7kg**



## FULL PART NUMBER FOR ORDERING

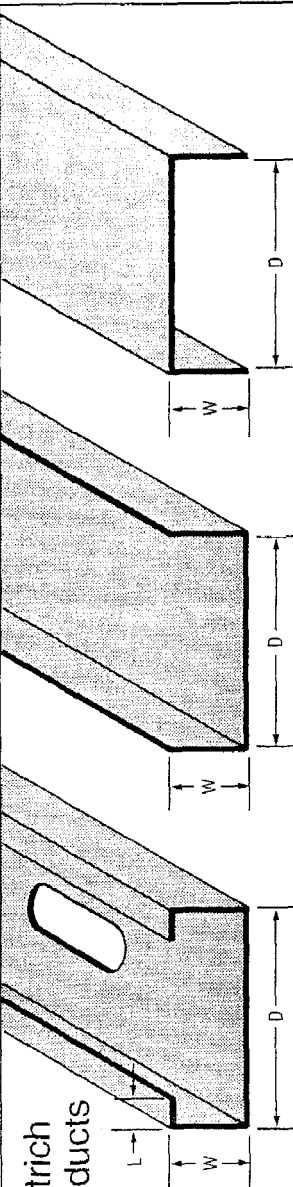
Axle Ø	Plain Bore	Plain Bore Keyway	Ball Bearing	Taper Roller Bearing
<b>METRIC AXLES</b>				
12		SFH100/40/KM 12	SFH100/40/BJM 12	
20		SFH100/40/KM 20	SFH100/40/BJM 20	
25		SFH100/40/KM 25	SFH100/40/BJM 25	
30		SFH100/40/KM 30		

Wheels fitted with ball journals are pre-lubricated, double shielded. Alternatively greasing can be through the axle - state if this option is required when ordering

## Table of Contents

	page
About Dietrich Industries, Technical Support, Codes and Specifications, Steel Thicknesses	2
Dietrich Products, Accessories, Slip Track Details, Physical Structural Definitions	3
Physical Structural Properties of	
2-1/2" Studs and Track	4
3-1/2", 3-5/8", 4" and 5-1/2" Studs and Track	5, 6
6" and 8" Studs and Track	7, 8
10 and 12" Studs and Track	9, 10
14" and 16" Studs and Track	11
TSC Track (2" Leg)	12
Fastener Information	13
Allowable Shear and Web Crippling Values	14
Accessories and Bridging Details	15
Additional Literature / Plant Locations	16

## Dietrich Products



### C STUDS

CODES	GAGES	W	L	D
CWN	20-14	1-3/8"	3/8"	2-1/2"-8"
CSJ	20-10	1-5/8"	1/2"	2-1/2"-16"
CSW	20-10	2"	5/8"	3-5/8"-16"
CSE	20-10	2-1/2"	5/8"	3-5/8"-16"
CSS	20-10	3"	1"	6"-16"
CSX	20-10	3-1/2"	1"	6"-16"

### TRACK

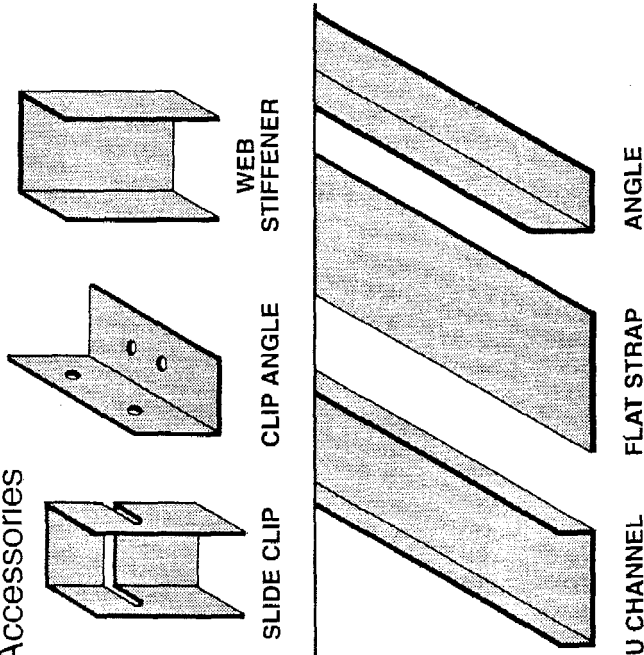
CODES	GAGES	W	D
TSA	20-10	1"	2-1/2"-16"
TSB	20-10	1-1/4"	2-1/2"-16"

### SLIP TRACK

CODES	GAGES	W	D
TSF	20-10	1-1/2"	2-1/2"-16"
TSC	20-10	2"	2-1/2"-16"
TSD	18-10	2-1/2"	2-1/2"-16"
TSE	16-10	3"	2-1/2"-16"
TSG	14-10	3-1/2"	3-5/8"-16"

NOTE: Codes are for single track application. Double track applications require a Special formed wider track. Consult your local plant for double track applications.

## Accessories



## Physical Structural Definitions

Area = Gross Area

$M_x$  = Fully braced allowable x-axis moment

$I_x$  = Moment of inertia about x-axis

$S_x$  = Section modulus about x-axis

$R_x$  = Radius of gyration about x-axis

$I_y$  = Moment of inertia about y-axis

$S_y$  = Section modulus about y-axis

$R_y$  = Radius of gyration about y-axis

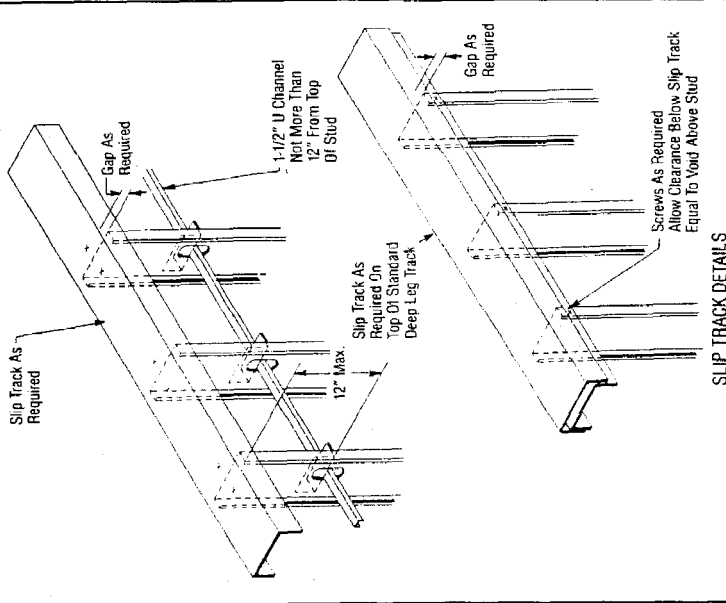
$X_o$  = Distance from shear center to centroid along principal y-axis

$J$  = St. Venant torsional constant

$C_w$  = Warping torsion constant

$R_o$  = Polar radius of gyration about shear center

$\beta = 1 - (X_o/R_o^2)$



SLIP TRACK DETAILS

## Physical Structural Properties—6" C Studs

MEMBER			GROSS SECTION PROPERTIES										EFFECTIVE SECTION PROPERTIES						TORSIONAL PROPERTIES						
			Flange (in.)	Lip (in.)	Design Thickness (in.)	Minimum Delivered Thickness (in.)	Weight (lb./ft.)	Area (in. <sup>2</sup> )	I <sub>x</sub> (in. <sup>4</sup> )	S <sub>x</sub> (in. <sup>3</sup> )	R <sub>x</sub> (in.)	I <sub>y</sub> (in. <sup>4</sup> )	S <sub>y</sub> (in. <sup>3</sup> )	R <sub>y</sub> (in.)	I <sub>x</sub> (in. <sup>4</sup> )	S <sub>x</sub> (in. <sup>3</sup> )	M <sub>x</sub> (in.-lb.)	I <sub>x</sub> (in. <sup>4</sup> )	S <sub>x</sub> (in. <sup>3</sup> )	M <sub>x</sub> (in.-lb.)	X <sub>0</sub> (in.)	J 1000 (in. <sup>4</sup> )	C <sub>w</sub> (in. <sup>6</sup> )	R <sub>0</sub> (in.)	β BETA
CWN	GAGE	20	1-3/8	3/8	0.0346	0.0329	1.047	0.320	1.597	0.532	2.234	0.070	0.065	0.466	1.597	0.513	10145				-0.820	0.128	0.496	2.425	0.886
		18	1-3/8	3/8	0.0451	0.0428	1.351	0.413	2.043	0.681	2.224	0.087	0.082	0.460	2.043	0.681	15016				-0.812	0.279	0.625	2.412	0.887
		16	1-3/8	3/8	0.0566	0.0538	1.682	0.514	2.519	0.840	2.214	0.105	0.098	0.452	2.519	0.840	18991	2.519	0.819	27587	-0.804	0.550	0.758	2.398	0.888
		14	1-3/8	3/8	0.0713	0.0677	2.091	0.639	3.094	1.031	2.200	0.125	0.117	0.443	3.094	1.031	24034	3.094	1.031	35649	-0.793	1.082	0.911	2.380	0.889
CSJ		20	1-5/8	1/2	0.0346	0.0329	1.132	0.346	1.808	0.603	2.286	0.118	0.097	0.583	1.808	0.538	11516				-1.088	0.138	0.855	2.598	0.825
		18	1-5/8	1/2	0.0451	0.0428	1.461	0.447	2.316	0.772	2.277	0.148	0.123	0.577	2.316	0.772	16764				-1.080	0.302	1.082	2.585	0.826
		16	1-5/8	1/2	0.0566	0.0538	1.821	0.557	2.862	0.954	2.268	0.181	0.149	0.570	2.862	0.954	21175	2.862	0.928	30753	-1.071	0.595	1.318	2.572	0.826
		14	1-5/8	1/2	0.0713	0.0677	2.266	0.693	3.524	1.175	2.255	0.218	0.180	0.561	3.524	1.174	26767	3.524	1.174	39811	-1.061	1.173	1.595	2.555	0.828
CSW		12	1-5/8	1/2	0.1017	0.0966	3.174	0.970	4.841	1.614	2.234	0.287	0.237	0.544	4.841	1.613	38533	4.841	1.613	57017	-1.034	3.344	2.102	2.521	0.832
		10	1-5/8	1/2	0.1242	0.1180	3.833	1.171	5.773	1.924	2.220	0.333	0.275	0.533	5.773	1.924	47354	5.773	1.924	69858	-1.013	6.025	2.423	2.498	0.835
		20	2	5/8	0.0346	0.0329	1.246	0.381	2.090	0.697	2.343	0.211	0.148	0.745	2.051	0.610	12049				-1.474	0.152	1.583	2.867	0.736
		18	2	5/8	0.0451	0.0428	1.609	0.492	2.683	0.894	2.336	0.268	0.188	0.739	2.683	0.874	17261				-1.467	0.333	2.011	2.855	0.736
CSW		16	2	5/8	0.0566	0.0538	2.006	0.613	3.322	1.107	2.327	0.329	0.230	0.732	3.322	1.107	24082	3.322	1.004	30057	-1.459	0.656	2.462	2.842	0.737
		14	2	5/8	0.0713	0.0677	2.499	0.764	4.099	1.366	2.316	0.400	0.280	0.723	4.099	1.366	30395	4.099	1.337	44391	-1.448	1.293	2.995	2.826	0.737
		12	2	5/8	0.1017	0.0966	3.507	1.072	5.656	1.885	2.297	0.536	0.375	0.707	5.656	1.885	43625	5.656	1.885	64788	-1.421	3.694	3.995	2.792	0.741
		10	2	5/8	0.1242	0.1180	4.239	1.296	6.762	2.254	2.284	0.628	0.440	0.696	6.762	2.253	53499	6.762	2.253	79242	-1.399	6.663	4.646	2.768	0.744
CSE		20	2-1/2	5/8	0.0346	0.0329	1.359	0.415	2.399	0.800	2.403	0.359	0.206	0.930	2.267	0.636	12577				-1.905	0.166	2.650	3.204	0.647
		18	2-1/2	5/8	0.0451	0.0428	1.756	0.537	3.082	1.027	2.396	0.458	0.263	0.923	3.064	0.918	18149				-1.897	0.363	3.377	3.193	0.647
		16	2-1/2	5/8	0.0566	0.0538	2.192	0.670	3.822	1.274	2.389	0.563	0.323	0.917	3.822	1.159	22909	3.636	1.069	32018	-1.889	0.716	4.148	3.180	0.647
		14	2-1/2	5/8	0.0713	0.0677	2.733	0.835	4.726	1.575	2.379	0.688	0.395	0.908	4.726	1.522	33141	4.667	1.343	40195	-1.878	1.414	5.068	3.164	0.648
CSS		12	2-1/2	5/8	0.1017	0.0966	3.840	1.174	6.540	2.180	2.361	0.932	0.535	0.891	6.540	2.179	49029	6.540	2.090	70069	-1.851	4.045	6.818	3.130	0.650
		10	2-1/2	5/8	0.1242	0.1180	4.646	1.420	7.834	2.611	2.349	1.100	0.631	0.880	7.834	2.610	59976	7.834	2.589	88453	-1.828	7.302	7.981	3.104	0.653
		20	3	1	0.0346	0.0329	1.557	0.476	2.831	0.944	2.439	0.656	0.340	1.174	2.489	0.634	12533				-2.619	0.190	5.724	3.767	0.516
		18	3	1	0.0451	0.0428	2.014	0.616	3.644	1.215	2.433	0.841	0.435	1.169	3.436	0.997	19704				-2.613	0.417	7.317	3.756	0.516
CSS		16	3	1	0.0566	0.0538	2.516	0.769	4.526	1.509	2.426	1.039	0.537	1.162	4.486	1.366	26999	4.308	1.262	37788	-2.605	0.822	9.020	3.745	0.516
		14	3	1	0.0713	0.0677	3.141	0.960	5.608	1.869	2.417	1.279	0.661	1.154	5.608	1.841	36376	5.597	1.701	50920	-2.596	1.625	11.072	3.730	0.516
		12	3	1	0.1017	0.0966	4.422	1.351	7.790	2.597	2.401	1.753	0.906	1.139	7.790	2.595	57233	7.790	2.564	84479	-2.570	4.658	15.030	3.697	0.517
		10	3	1	0.1242	0.1180	5.357	1.637	9.353	3.118	2.390	2.085	1.077	1.129	9.353	3.115	69959	9.353	3.115	104299	-2.547	8.420	17.708	3.671	0.519
CSX		20	3-1/2	1	0.0346	0.0329	1.670	0.511	3.139	1.046	2.480	0.939	0.423	1.356	2.661	0.652	12876				-3.085	0.204	8.130	4.184	0.456
		18	3-1/2	1	0.0451	0.0428	2.162	0.661	4.043	1.348	2.474	1.205	0.543	1.351	3.697	1.044	20634				-3.079	0.447	10.408	4.174	0.456
		16	3-1/2	1	0.0566	0.0538	2.701	0.826	5.026	1.675	2.467	1.492	0.671	1.344	4.863	1.442	28491	4.643	1.324	39634	-3.071	0.883	12.851	4.163	0.456
		14	3-1/2	1	0.0713	0.0677	3.374	1.031	6.234	2.078	2.459	1.840	0.827	1.336	6.234	1.947	38465	6.070	1.760	52689	-3.062	1.746	15.806	4.148	0.455
CSX		12	3-1/2	1	0.1017	0.0966	4.754	1.453	8.675	2.892	2.443	2.533	1.138	1.320	8.675	2.888	62765	8.675	2.537	75972	-3.036	5.008	21.543	4.115	0.456
		10	3-1/2	1	0.1242	0.1180	5.763	1.761	10.425	3.475	2.433	3.022	1.358	1.310	10.425	3.473	76680	10.425	3.336	110054	-3.013	9.059	25.455	4.088	0.457

## 6" Track

TSB	20	1-1/4" LEG	0.0346	0.0329	0.956	0.292	1.393	0.459	2.183	0.032	0.034	0.340	1.239	0.326	6435					-0.524	0.117	0.231	2.271	0.947
	18	1-1/4" LEG	0.0451	0.0428	1.242	0.379	1.808	0.594	2.183	0.041	0.043	0.338	1.688	0.505	9970					-0.522	0.257	0.298	2.270	0.947
	16	1-1/4" LEG	0.0566	0.0538	1.557	0.476	2.267	0.742	2.183	0.054	0.054	0.336	2.066	0.671	13257					-0.520	0.509	0.371	2.269	0.948
	14	1-1/4" LEG	0.0713	0.0677	1.953	0.597	2.843	0.926	2.182	0.067	0.067	0.334	2.843	0.891	17611					-0.517	1.011	0.461	2.267	0.948
TSB	12	1-1/4" LEG	0.1017	0.0966	2.778	0.849	4.050	1.306	2.184	0.092	0.092	0.328	4.050	1.305	29367					-0.509	2.926	0.643	2.267	0.950
	10	1-1/4" LEG	0.1242	0.1180	3.389	1.036	4.955	1.586	2.187	0.109	0.107	0.324	4.955	1.585	36426					-0.501	5.327	0.773	2.267	0.951

NOTE: Reference typical notes on page 4.



DAVE FRISBY

1320 Lincoln Road • Idaho Falls, ID 83401  
 208-523-7727 • FAX 529-2674 • 1-800-509-7727 (SPAS)  
[www.snakeriverspa.com](http://www.snakeriverspa.com)



**HotSpring™**  
 Portable Spas

- Tiger River Portable Spas
- Hot Spot Anywhere, Anytime Tub
- Connelly Billiard Tables
- Billiard & Dart Accessories
- Viking Pools
- Finnleo Sauna and Steam Rooms
- Bio Guard Water Care Products
- Soft Soak Water Care Products
- Spa & Pool Accessories
- Free Water Analysis

EDF Title: PM-2A Half Tank Positive Air Flow System

Project No.: 2000-096

Project Title: PM-2A Tanks and Burn Pits RD/RAWP

**Problem Statement:**

Design a system that will provide positive air flow during the sludge removal of the PM-2A half tanks. The air flow is to be through the 5' X 12' 6" work space opening, through the half tank, out the end of the half tank, through a HEPA filter and exhausted to the atmosphere.

**Summary of Conclusions:**

The designed system is shown in the attached Design Sketches. The design uses an end plate on the half tank to support the end of the plastic cover and provide a connection for the duct work that leads to a HEPA filter. An axial in line fan installed in the outlet duct of the HEPA filter provides the air flow of 1350 cfm through the half tank and filter and exhausts to the atmosphere. The fan is capable of providing the 1350 cfm for up to 73% increase in filter resistance and will still provide 1000 cfm for a 118% increase in filter resistance.

**Review and Approval Signatures:**

	R/A	Printed Name	Signature	Date
Prepared by:		Herbert L Magleby	<i>Herbert L Magleby</i>	7/10/03
Checked by:		KEVIN SWABER	<i>Kevin Swaber</i>	10/20/03
Approval:		GARY MECHAM	<i>Gary Mecham</i>	10/21/03

**Distribution:**

Professional Engineer's Stamp (if required)



EDF Title: PM-2A Half Tank Air Flow		EDF- 096 - 014	
Project No.: 2000-096		Rev No.:	
Project Title: PM-2A Tanks and Burn Pits RD/RAWP		Page 2 of 2	
Prepared by:	Date:	Checked by:	Date:

### Problem Statement:

Design a system that will provide positive air flow during the sludge removal of the PM-2A half tanks. The air is to flow into the tank through the 5' X 12' 6" work space opening, through the half tank, out at the end of the half tank, through a HEPA filter and exhausted to the atmosphere.

### Assumptions:

An air flow of ¼ miles per hour through the half tank will provide adequate positive air flow.

### References:

Crane Technical Paper No. 410, Flow of Fluids Through Valves, Fittings, and Pipe.

### Calculations / Analysis:

The design is shown on the attached Design Sketches Sheets 1 and 2 and on the Drawing, Half Tank Positive Air Flow, included with the design drawings for the project. The Design includes an 18 inch wide aluminum plate across the half tank at the end of the tank where the vacuum system is located. The plate has a fixed channel on the bottom across the end with a sponge rubber seal. Movable channels with sponge rubber seals are attached to the bottom of the plate across the 18 inch dimension along the half tank sides. The design scheme is to push the plate up snug to seal the end then move the two side channels in snug and secure them in place with bolts in slots that extend up through the aluminum plate. A plate with bolts is provided on the other edge of the plate across the open tank to secure the end of the plastic cover. This scheme will provide a seal for the plate to the tank and secure it in place and will secure the end of the plastic cover.

A 10 inch hole with a stub is located in the center of the plate to provide a connection for the flexible duct that connects to a HEPA filter. A rigid duct is used to connect the outlet of the filter to an in-line fan. The air flow, then, is in through the work space in the plastic cover, along the half tank to the end, out the end through the 10 inch duct, to the HEPA filter, out of the HEPA filter through the in-line fan and exhausted to the atmosphere. The exhaust is directed up at an angle to avoid impacting the construction site and creating dust. A flexible duct, MOPECO M-30646, is used for the connection from the half tank cover plate to the HEPA filter to allow the plate to be moved to the second tank and moved to provide access to the ends of the half tanks for sludge removal and half tank cleaning as described below.

The HEPA filter chosen for the design is the standard Flanders G Series 24" X 24" housing with a GGF 24" X 24" X 11 ½" deep filter. The filter is rated for a 1500 cfm with a 1.3" w.g. pressure differential. The axial in-line fan is an ACME In-Line Airfoil Centrifugal Fan Model 2115 with a partial width wheel that is rated at 3.0" w.g. at 1350 cfm. Calculations were made of the system head loss that show that the Fan Model 2115 is capable of delivering 1350 cfm with a clean new filter and will be able to deliver 1350 cfm for up to 73% increase in filter resistance. The fan will still deliver 1000 cfm with a 118% increase in filter resistance. The 1000 cfm will still provide good positive air flow and the design is acceptable. The attached Design Calculations show the air flow calculations.

A similar 18 inch wide cover plate will be used to secure the end of the plastic cover at the other end of the half tank. This plate will not need the stub for the 10 inch air duct.

For removing the sludge and cleaning the half tanks at the ends under the 18 inch wide end plates, the side seals can be moved out and the plates lifted and slide toward the center of the tanks to allow access. The system can continue to operate with an end plate moved and provide some positive air flow. With the end plate moved at the far end, air will still be drawn down the tank and out through the filter by the fan and exhausted to the atmosphere. The flexible duct allows the cover to be lifted and moved on the end near the HEPA filter and air from the working area at the end of the tank will be drawn through the filter by the fan and exhausted to the atmosphere.

## DESIGN SCKETCHES



A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-2A Half Tank Air Flow

SHEET NO. Design Sketch 1 OF 1

CALCULATED BY Lowell

DATE 1/3/03

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE \_\_\_\_\_

1 Cover See Detail Sheet 2

2. 10" Duct

3. HEPA Filter  
Flanders G Series

CIF-66F-304 Housing for 24"x24"  
filters. Order with stubs for 10" duct  
connections.

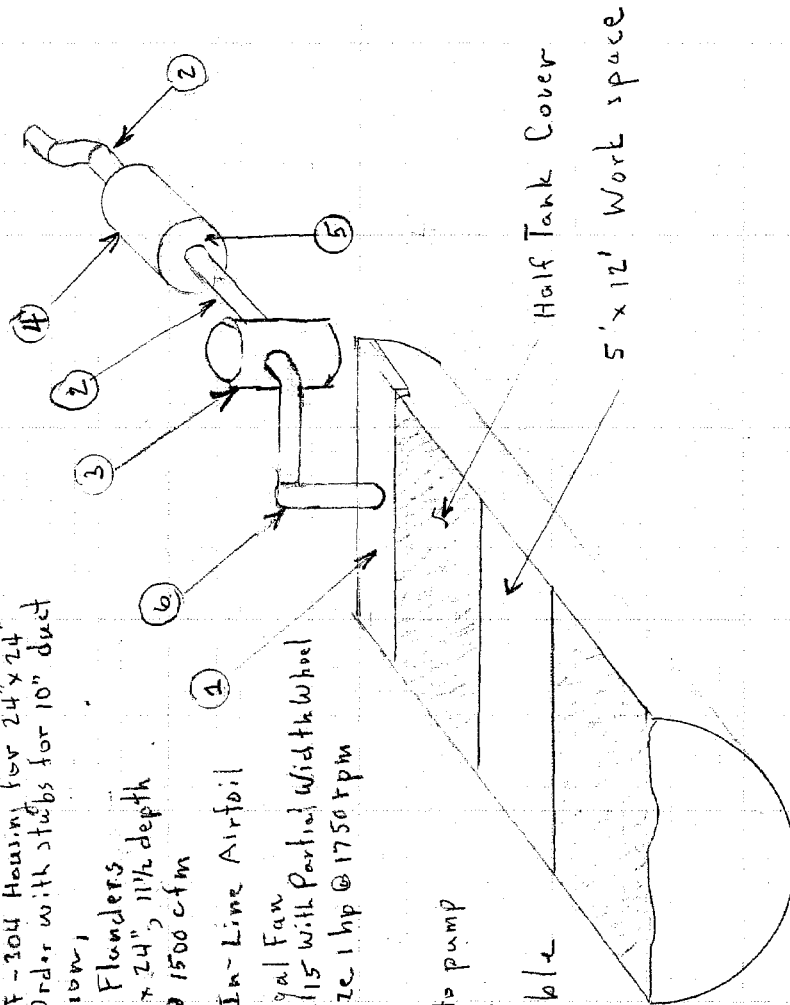
Filters Flanders  
66F 24"x24", 11 1/2" depth  
1/3" Wg @ 1500 cfm

4. ACME In-Line Airfoil

Centrifugal Fan  
Model 2115 with Partial Wheel  
Motor size 1 hp @ 1750 rpm

5. Flange  
10" duct to pump  
housing.

6. 10" Flexible  
Duct



Positive Air Flow System  
PM-2A Tank Cleaning





A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-2A Half Tank Air Flow

SHEET NO. Design Sketch 2

OF \_\_\_\_\_

CALCULATED BY Lowell

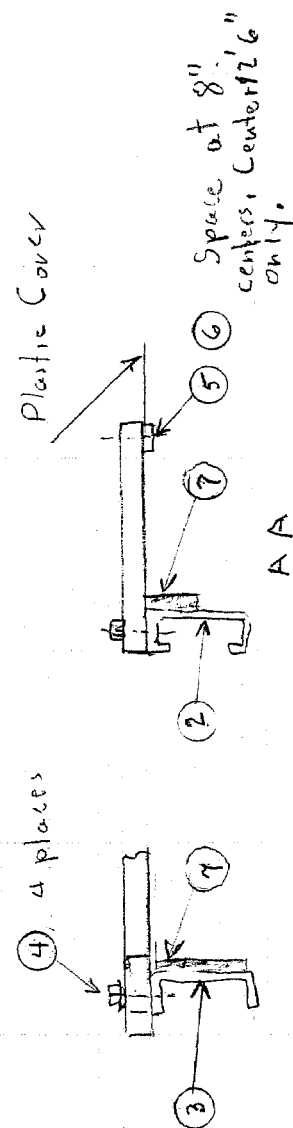
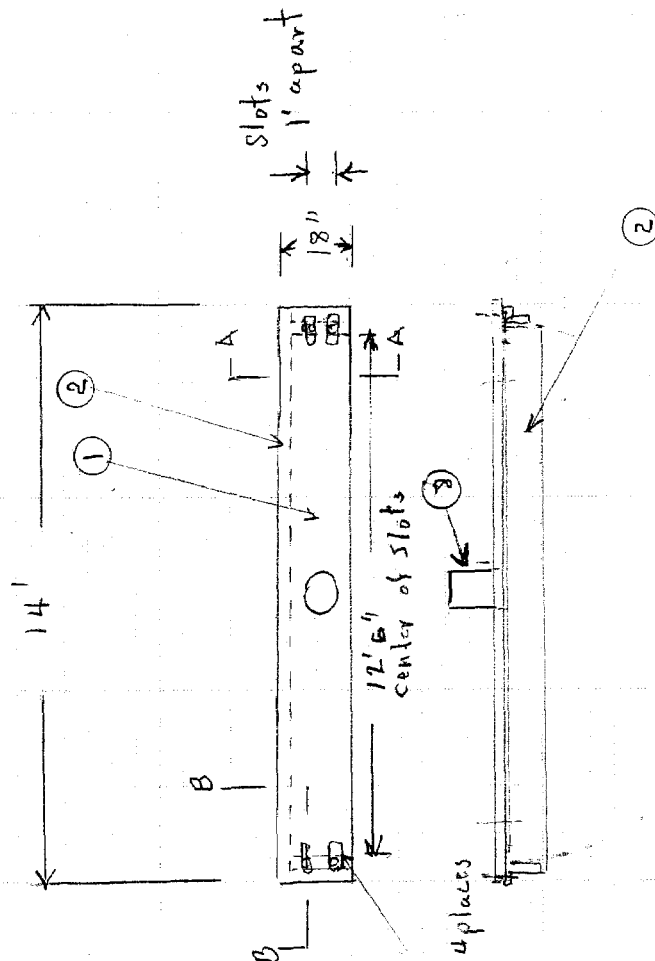
DATE 7/7/03

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE \_\_\_\_\_

- 1  $\frac{3}{8}$  Aluminum Plate
- 2 Dietrich 6" C stud
- 3 CSS 16 gage
- 4 Dietrich U channel
- 5 CHN 3 2" 16 gage
- 6  $\frac{3}{8}$ " x 1" bolts washers and nuts
- 7 Dietrich 1" flat strap, 12' 6"
- 8  $\frac{1}{4}$ " x 1" bolt and nuts
- 9  $\frac{7}{16}$ " slots 2" long, 4 places
- 10 2" x  $\frac{1}{2}$ " sponge rubber strip or similar seal strip.
- 11 8, 10" stub for 10" air duct connection



PM-2A Half Tank End Air Flow Connection and End Plastic Cover Support  
(Other End Same Except without 10" Stub for duct connection)

## DESIGN CALCULATIONS



A New Type of Engineering Company  
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-2A Half Tank Air Flow.

SHEET NO. 0

OF

CALCULATED BY Lowell

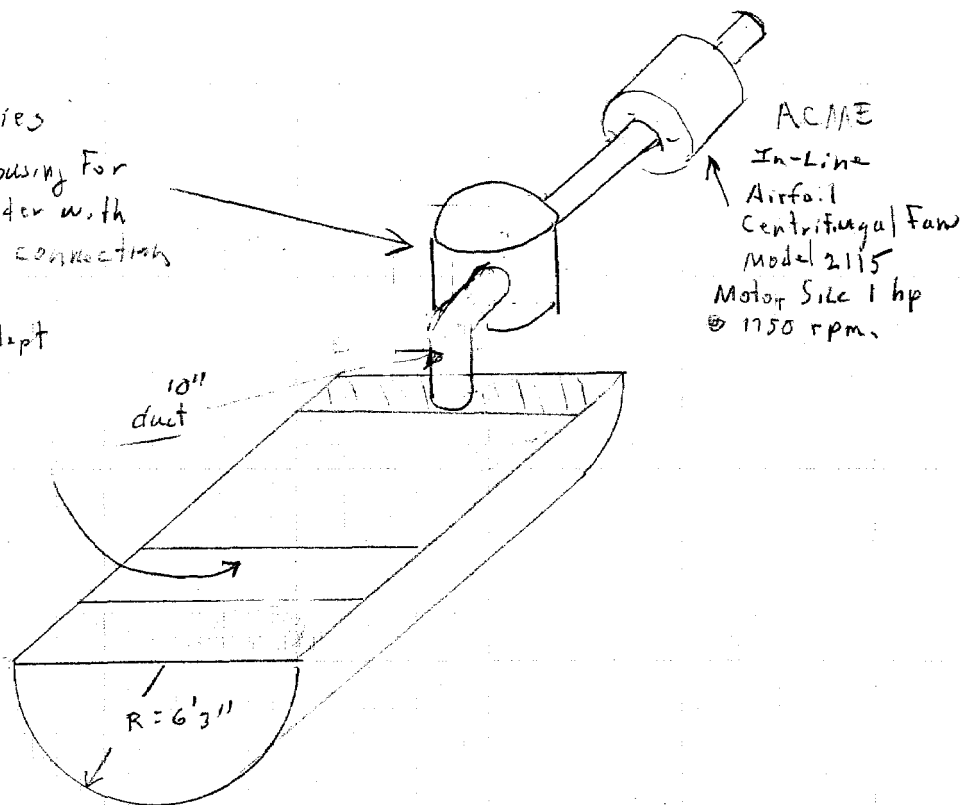
DATE 7/3/03

CHECKED BY

DATE

SCALE

HEPA Filter  
Flanders G Series  
CIF-GGF-304 Housing For  
24"x24" filters. Order with  
stubs for 10" duct connections  
Filter Flanders  
GGF 24"x24", 11 1/2" dept  
1.3"wg @ 1500 cfm



Assume flow rate in tank to be 1/4 mph

$$v = 0.25 \frac{\text{mi}}{\text{hr}} \cdot \frac{5280 \text{ ft}}{\text{mi}} \cdot \frac{\text{hr}}{3600 \text{ sec}} = 0.367 \text{ ft/sec}$$

Flow area of tank

$$A = \frac{1}{2} \pi R^2 = \frac{1}{2} \pi (6.25)^2 = 61.36 \text{ ft}^2$$

Flow volume

$$V_0 = 0.367 \frac{\text{ft}}{\text{sec}} \cdot \frac{60 \text{ sec}}{\text{min}} \cdot 61.36 \text{ ft}^2 = 1,350 \text{ ft}^3/\text{min}$$



A New Type of Engineering Company  
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-2A Half Tank Air Flow

SHEET NO. 1

OF

CALCULATED BY Lowell

DATE 7/8/03

CHECKED BY

DATE

SCALE

Determine pressure loss through duct and fittings

Reference Flow of Fluids through Valves, Fittings and pipe.  
by the Engineering Division Crane Co. Chicago.  
Technical Paper No. 410 Copyright 1957 Crane Co.

Page 1-6

The Darcy equation

$$h_L = \frac{fL}{D} \frac{v^2}{2g} \quad \text{feet of liquid}$$

with suitable restrictions may be used when gases and vapors (compressible fluids) are being handled.

Page 1-7

If the calculated pressure drop ( $P_1 - P_2$ ) is then about 10% of the inlet pressure  $P_1$ , reasonable accuracy will be obtained if the specific volume used in the formula is based upon either the upstream or downstream conditions, whichever is known.

For our case the inlet pressure is atmospheric. 10% of atmospheric is

$$\Delta h_{\max} = 0.10 \times 14.7 \frac{\text{lb}}{\text{in}^2} \times \frac{144 \text{ in}^2}{\text{ft}^2} \times \frac{\text{ft}^3}{62.4 \text{ lb}} \times \frac{12 \text{ in}}{\text{ft}} = 40.7 \text{ inches H}_2\text{O}$$

The total pressure  $\Delta P$  for the system is expected to be about 3 inches of water which is well below the 40.7 inches of the upper limit for the Darcy equation and therefore the Darcy equation will be used.



A New Type of Engineering Company  
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-7A Half Tank Air Flow

SHEET NO. 2

OF

CALCULATED BY Lewell

DATE 7/8/03

CHECKED BY

DATE

SCALE

Calculate the Reynolds number for the 10" air duct

$$\text{hydraulic radius} = \frac{\text{area of flow}}{\text{wetted perimeter}} = \frac{\pi D^2}{4 \pi D} = \frac{D}{4}$$

$$\text{equivalent diameter} = 4 \times \text{hydraulic radius} = 4 \times \frac{D}{4} = D$$

$$D = 10/12 = 0.833 \text{ ft. } d = 10''$$

Page 3-2

$$Re = \frac{123.9 d n \rho}{\mu}$$

$$A = \pi D^2 / 4 = \frac{\pi (0.833)^2}{4} = 0.545 \text{ ft}^2$$

$n$  = mean velocity in feet per second.

$$n = \frac{1350 \text{ ft}^3}{\text{min}} \times \frac{1}{0.545 \text{ ft}^2} \times \frac{\text{min}}{60 \text{ sec}} = 41.28 \text{ ft/sec}$$

$$\rho = \text{weight density, lbs/ft}^3$$
$$= 0.07528 \text{ lb/ft}^3$$

$\mu$  = absolute viscosity in centipoise

Page A-5

$$\mu = 0.018 \text{ centipoise}$$

$$Re = \frac{(123.9)(10)(41.28)(0.07528)}{0.018} = 2.119 \times 10^5$$

From Chart A-24 and a relative roughness  $\epsilon/D = .001$

$$f = 0.021$$

$$\frac{\text{ft}^2}{\text{sec}^2} \times \frac{\text{sec}^2}{\text{ft}} = \text{ft}$$

For 100 ft of duct

$$h(\text{feet of air}) = \frac{f L V^2}{D 2 g_c} = \frac{(0.021)(100)}{0.833} \times \frac{(41.28)^2}{(2)(32.2)} = 66.71 \text{ ft air}$$

$$\Delta P = h_p = 66.71 \text{ ft} \times 0.07528 \frac{\text{lb}}{\text{ft}^3} = 5.02 \text{ lb/ft}^2$$

$$h(\text{feet of water}) = \frac{\Delta P}{\rho_w} = \frac{5.02 \text{ lb}}{\text{ft}^2} \times \frac{\text{ft}^3}{62.4 \text{ lb}} = .080 \text{ ft H}_2\text{O}$$

$$h(\text{inches of water}) = .080 \times 12 = 0.965 \text{ inches water per 100' duct.}$$

$$h(\text{inches of water per foot of duct}) = 0.010 \text{ inches,}$$



A New Type of Engineering Company  
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB DM-2A Half Tank Air Flow

SHEET NO. 3

OF \_\_\_\_\_

CALCULATED BY Lowell

DATE 7/9/03

CHECKED BY \_\_\_\_\_

DATE \_\_\_\_\_

SCALE \_\_\_\_\_

Determine Equivalent Length. Charts A-26 and A-27

Entrance from half tank to duct.

$$K = 0.50$$

Exit duct to atmosphere

$$K = 1.00$$

Total

$$= 1.50$$

$$K = \frac{fL}{D} \quad L = \frac{KD}{f}$$

$$L = \frac{(1.5)(0.833)}{0.021} = 59.5 \text{ ft.}$$

Use 2 90° bends at  $r/d = 4$ . Use bend resistance.

Resistance due to length is included in duct length

$L/D$  per bend = 8 for 2 bends  $L/D = 16$

$$L = (16)(0.833) = 13 \text{ ft.}$$

Total length.

Duct from tank to filter 30'

Duct from filter to pump 3

Duct from pump to atmosphere 4

Entrance + Exit 60'

Duct bends 13'

Total equivalent length 112'

$$\text{Total head (without filter)} = (0.010)(112) = 1.1 \text{ inch H}_2\text{O.}$$

0.010 inches  $\text{H}_2\text{O}$  head loss per equivalent foot of pipe from sheet 2



A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-2A H<sub>2</sub>F Tank A - Flow

SHEET NO. 4.

OF

CALCULATED BY Lowell

DATE 7/9/03

CHECKED BY

DATE

SCALE

The axial flow fan will develop 3" head at 1350 cfm. The filter is rated at 1500 cfm with 1.3 inches water head loss. For 1350 cfm the head loss would be

$$h_{\text{filter}} = \left(\frac{1350}{1500}\right)^2 1.3 \approx 1.1 \text{ inches water.}$$

Head loss available for the filter is  $h = 3 - 1.1 = 1.9$  inches

The system will provide 1350 cfm

for up to a  $(1.9 - 1.1) / (1.1) = 73\%$  increase in filter head loss.

The characteristic of the axial fan is that the developed head remains about 3" H<sub>2</sub>O for a considerable range of flow below 1350 cfm. The head loss of the

ducts and entrance and exit losses varies as the square of the flow rate. If the filter resistance increases as particles are filtered out the flow will decrease,

and head loss of the duct will decrease. If the flow were to decrease to 1000 cfm the duct head loss would be

$$h_{1000 \text{ cfm}} = 1.1 \left(\frac{1000}{1350}\right)^2 = 0.604 \text{ " H}_2\text{O}$$

and  $3 - 0.6 = 2.4$  inches H<sub>2</sub>O would be available for the filter. 1000 cfm would still provide good positive flow therefore the filters in the filter housing would not need to be replaced until the filter head loss increased to

$$\% \text{ Increase} = \frac{2.4 - 1.1}{1.1} = 118\%$$

The system will provide good positive flow even with a large increase in filter resistance and is an adequate design.



A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM-21A Half Tank Air Flow

SHEET NO. 5

OF

CALCULATED BY

DATE

CHECKED BY

DATE

SCALE

As a rough check of line loss use Simplified Flow Formula  
for Compressible Fluids Page 3-22 Crane.

The pressure drop per 100 feet of pipe.

For flow of 1,350 CFM

$P = .07528 \text{ lb/ft}^3$  Page A-8

$$\begin{aligned} W &= 1,350 \frac{\text{ft}^3}{\text{min}} \cdot .07528 \frac{\text{lb}}{\text{ft}^3} \cdot 60 \frac{\text{min}}{\text{hr}} \\ &= 6,098 \text{ lb/hr} \\ &= 6.098 \text{ thousands of pounds per hr} \end{aligned}$$

$C_1 = 0.037$  Chart Page 3-22

For 10" schedule 20 (Approximation for flexible duct)

$C_2 = 0.0397$  Table Page 3-23

$$\Delta P_{100} = \frac{C_1 C_2}{P} = \frac{(0.037)(0.0397)}{.07528} = 0.020 \text{ psi}$$

$$h = 0.020 \frac{\text{lb}}{\text{in}^2} \cdot \frac{144 \text{ in}^2}{\text{ft}^2} \cdot \frac{1 \text{ ft}^3}{62.4 \text{ lb}} = 0.046 \text{ ft water}$$

$$\Delta h \text{ inches of water} = .046 \times 12 = 0.552 \text{ inches water, per 100 ft of pipe.}$$

Calculation using Darcy equation is 0.965 inches water per 100 ft of pipe

The Darcy equation clearly gives conservative results and results of the Darcy Equation analysis will be used to justify design.



## **CRANE FLOW OF FLUIDS EQUATIONS AND CHARTS**

# Nomenclature

Unless otherwise stated, all symbols used  
in this book are defined as follows:

$A$  = cross sectional area of pipe or orifice, in square feet  
 $a$  = cross sectional area of pipe or orifice, in square inches  
 $B$  = rate of flow in barrels (42 gallons) per hour  
 $C$  = flow coefficient for orifices and nozzles = discharge coefficient corrected for velocity of approach =  $C_d / \sqrt{1 - (d_0/d_1)^4}$   
 $C_d$  = discharge coefficient for orifices and nozzles  
 $C_v$  = flow coefficient for valves; expresses flow rate in gallons per minute of 60 F water with 1.0 psi pressure drop across valve =  $Q \sqrt{\rho / (62.4 \Delta P)}$   
 $D$  = internal diameter of pipe, in feet  
 $d$  = internal diameter of pipe, in inches  
 $e$  = base of natural logarithm = 2.718  
 $f$  = friction factor in formula  $h_L = f L v^2 / D 2g$   
 $g$  = acceleration of gravity = 32.2 feet per second per second  
 $H$  = total head, in feet of fluid  
 $h$  = static pressure head existing at a point, in feet of fluid  
 $h_g$  = total heat of steam, in Btu per pound  
 $h_L$  = loss of static pressure head due to fluid flow, in feet of fluid  
 $h_w$  = static pressure head, in inches of water  
 $K$  = resistance coefficient or velocity head loss in the formula,  $h_L = K v^2 / 2g$   
 $k$  = ratio of specific heat at constant pressure to specific heat at constant volume =  $c_p / c_v$   
 $L$  = length of pipe, in feet  
 $L/D$  = equivalent length of a resistance to flow, in pipe diameters  
 $L_m$  = length of pipe, in miles  
 $M$  = molecular weight  
 $MR$  = universal gas constant = 1544  
 $n$  = exponent in equation for polytropic change ( $p' V^n = \text{constant}$ )  
 $P$  = pressure, in pounds per square inch gauge  
 $P'$  = pressure, pounds per square inch absolute  
*(see page 1-5 for diagram showing relationship between gauge and absolute pressure)*  
 $p'$  = pressure, in pounds per square foot absolute  
 $Q$  = rate of flow, in gallons per minute  
 $q$  = rate of flow, in cubic feet per second at flowing conditions  
 $q'$  = rate of flow, in cubic feet per second at standard conditions (14.7 psia and 60F)  
 $q'_a$  = rate of flow, in millions of standard cubic feet per day, MMscfd  
 $q'_h$  = rate of flow, in cubic feet per hour at standard conditions (14.7 psia and 60F), scfh  
 $q_m$  = rate of flow, in cubic feet per minute at flowing conditions  
 $q'_m$  = rate of flow, in cubic feet per minute at std. conditions (14.7 psia and 60F), scfm

$R$  = individual gas constant =  $MR/M = 1544/M$   
 $R_e$  = Reynolds number  
 $r_c$  = critical pressure ratio for compressible flow  
 $S$  = specific gravity of liquids relative to water, both at standard temperature (60 F)  
 $S_g$  = specific gravity of a gas relative to air = the ratio of the molecular weight of the gas to that of air  
 $T$  = absolute temperature, in degrees Rankine (460 +  $t$ )  
 $t$  = temperature, in degrees Fahrenheit  
 $\bar{V}$  = specific volume of fluid, in cubic feet per pound  
 $V$  = mean velocity of flow, in feet per minute  
 $V_a$  = volume, in cubic feet  
 $v$  = mean velocity of flow, in feet per second  
 $v_s$  = sonic (or critical) velocity of flow of a gas, in feet per second  
 $\dot{W}$  = rate of flow, in pounds per hour  
 $w$  = rate of flow, in pounds per second  
 $w_a$  = weight, in pounds  
 $x$  = percent quality of steam = 100 minus percent of moisture  
 $Y$  = net expansion factor for compressible flow through orifices, nozzles, or pipe  
 $Z$  = potential head or elevation above reference level, in feet

## Subscripts

(o) . . indicates orifice or nozzle conditions unless otherwise specified  
 (1) . . indicates inlet or upstream conditions unless otherwise specified  
 (2) . . indicates outlet or downstream conditions unless otherwise specified  
 (100) . refers to 100 feet of pipe

## Greek Letters

### Delta

$\Delta$  = differential between two points

### Epsilon

$\epsilon$  = absolute roughness or effective height of pipe wall irregularities, in feet

### Rho

$\rho$  = weight density of fluid, pounds per cubic ft  
 $\rho'$  = density of fluid, grams per cubic centimeter

### Mu

$\mu$  = absolute (dynamic) viscosity, in centipoise  
 $\mu_e$  = absolute viscosity, in pound mass per foot second or poundal seconds per sq foot  
 $\mu'_e$  = absolute viscosity, in slugs per foot second or pound force seconds per square foot

### Nu

$\nu$  = kinematic viscosity, in centistokes  
 $\nu'$  = kinematic viscosity, square feet per second

## Darcy's Formula General Equation for Flow of Fluids

Flow in pipe is always accompanied by friction of fluid particles rubbing against one another, and consequently, by loss of energy available for work; in other words, there must be a pressure drop in the direction of flow. If ordinary Bourdon tube pressure gauges were connected to a pipe containing a flowing fluid, as shown in Figure 1-6, gauge  $P_1$  would indicate a higher static pressure than gauge  $P_2$ .

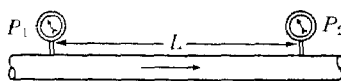


Figure 1-6

The general equation for pressure drop, known as Darcy's formula and expressed in feet of fluid, is  $h_L = fLv^2/D 2g$ . This equation may be written to express pressure drop in pounds per square inch, by substitution of proper units, as follows:

$$\Delta P = \frac{\rho f L v^2}{1.44 D 2g} \quad \text{Equation 1-4}$$

(For other forms of this equation, see page 3-2.)

The Darcy equation is valid for laminar or turbulent flow of any liquid in a pipe. However, when extreme velocities occurring in a pipe cause the downstream pressure to fall to the vapor pressure of the liquid, cavitation occurs and calculated flow rates will be inaccurate. With suitable restrictions, the Darcy equation may be used when gases and vapors (compressible fluids) are being handled. These restrictions are defined on page 1-7.

Equation 1-4 gives the loss in pressure due to friction and applies to pipe of constant diameter carrying fluids of reasonably constant weight density in straight pipe, whether horizontal, vertical, or sloping. For inclined pipe, vertical pipe, or pipe of varying diameter, the change in pressure due to changes in elevation, velocity, and weight density of the fluid must be made in accordance with Bernoulli's theorem (page 1-5). For an example using this theorem, see page 4-8.

**Friction factor:** The Darcy formula can be rationally derived by dimensional analysis, with the exception of the friction factor,  $f$ , which must be determined experimentally. The friction factor for laminar flow conditions ( $R_e < 2000$ ) is a function of Reynolds number only; whereas, for turbulent flow ( $R_e > 4000$ ), it is also a function of the character of the pipe wall.

A region known as the "critical zone" occurs between Reynolds number of approximately 2000 and 4000. In this region, the flow may be either laminar or turbulent depending upon several factors; these include changes in section or direction of flow and obstructions, such as valves, in the upstream piping. The friction factor in this region is indeterminate and

has lower limits based on laminar flow and upper limits based on turbulent flow conditions.

At Reynolds numbers above approximately 4000, flow conditions again become more stable and definite friction factors can be established. This is important because it enables the engineer to determine the flow characteristics of any fluid flowing in a pipe, providing the viscosity and weight density at flowing conditions are known. For this reason, Equation 1-4 is recommended in preference to some of the commonly known empirical equations for the flow of water, oil, and other liquids, as well as for the flow of compressible fluids when restrictions previously mentioned are observed.

If the flow is laminar ( $R_e < 2000$ ), the friction factor may be determined from the equation:

$$f = \frac{64}{R_e} = \frac{64 \mu_e}{D v \rho} = \frac{64 \mu}{124 d v \rho}$$

If this quantity is substituted into Equation 1-4, the pressure drop in pounds per square inch is:

$$\Delta P = 0.000668 \frac{\mu L v}{d^2} \quad \text{Equation 1-5}$$

which is Poiseuille's law for laminar flow.

When the flow is turbulent ( $R_e > 4000$ ), the friction factor depends not only upon the Reynolds number but also upon the relative roughness,  $\epsilon/D$  . . . the roughness of the pipe walls ( $\epsilon$ ), as compared to the diameter of the pipe ( $D$ ). For very smooth pipes such as drawn brass tubing and glass, the friction factor decreases more rapidly with increasing Reynolds number than for pipe with comparatively rough walls.

Since the character of the internal surface of commercial pipe is practically independent of the diameter, the roughness of the walls has a greater effect on the friction factor in the small sizes. Consequently, pipe of small diameter will approach the very rough condition and, in general, will have higher friction factors than large pipe of the same material.

The most useful and widely accepted data of friction factors for use with the Darcy formula have been presented by L. F. Moody<sup>18</sup> and are reproduced on pages A-23 to A-25. Professor Moody improved upon the well-established Pigott and Kemler<sup>25, 26</sup> friction factor diagram, incorporating more recent investigations and developments of many outstanding scientists.

The friction factor,  $f$ , is plotted on page A-24 on the basis of relative roughness obtained from the chart on page A-23 and the Reynolds number. The

## Viscosity of Gases and Vapors

The curves for hydrocarbon vapors and natural gases in the chart at the upper right are taken from Maxwell<sup>16</sup>; the curves for all other gases in the chart are based upon Sutherland's formula, as follows:

$$\mu = \mu_0 \left( \frac{0.555 T_0 + C}{0.555 T + C} \right) \left( \frac{T}{T_0} \right)^{3/2}$$

where:

$\mu$  = viscosity, in centipoise at temperature  $T$ .

$\mu_0$  = viscosity, in centipoise at temperature  $T_0$ .

$T$  = absolute temperature, in degrees Rankine ( $460 + \text{deg. F}$ ) for which viscosity is desired.

$T_0$  = absolute temperature, in degrees Rankine, for which viscosity is known.

$C$  = Sutherland's constant.

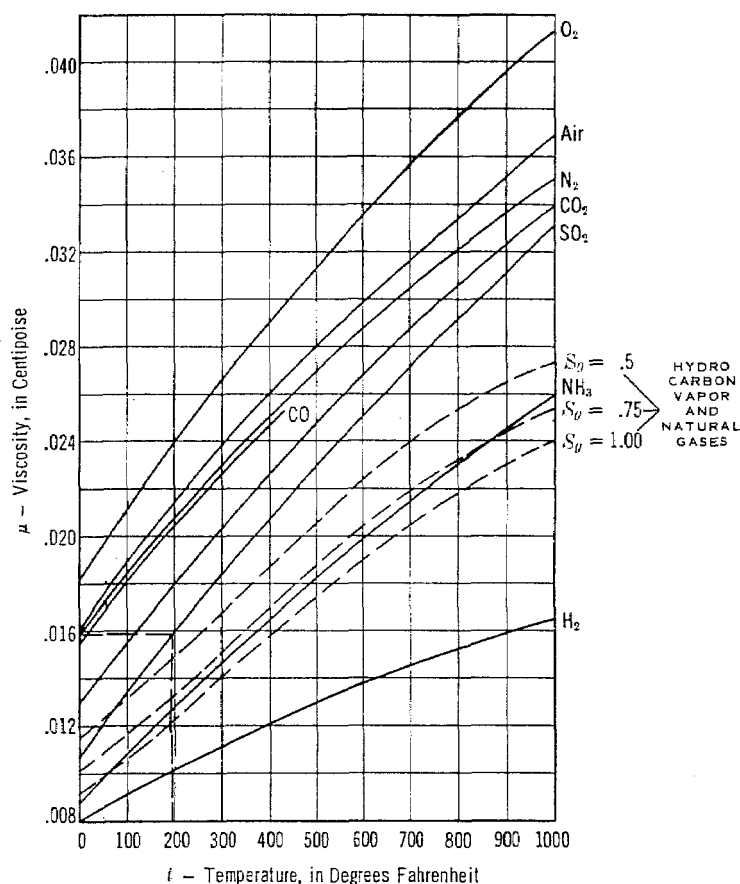
**Note:** The variation of viscosity with pressure is small for most gases. For gases given on this page, the correction of viscosity for pressure is less than 10 per cent for pressures up to 500 pounds per square inch.

Fluid	Approximate Values of "C"
O <sub>2</sub>	127
Air	120
N <sub>2</sub>	111
CO <sub>2</sub>	240
CO	118
SO <sub>2</sub>	416
NH <sub>3</sub>	370
H <sub>2</sub>	72

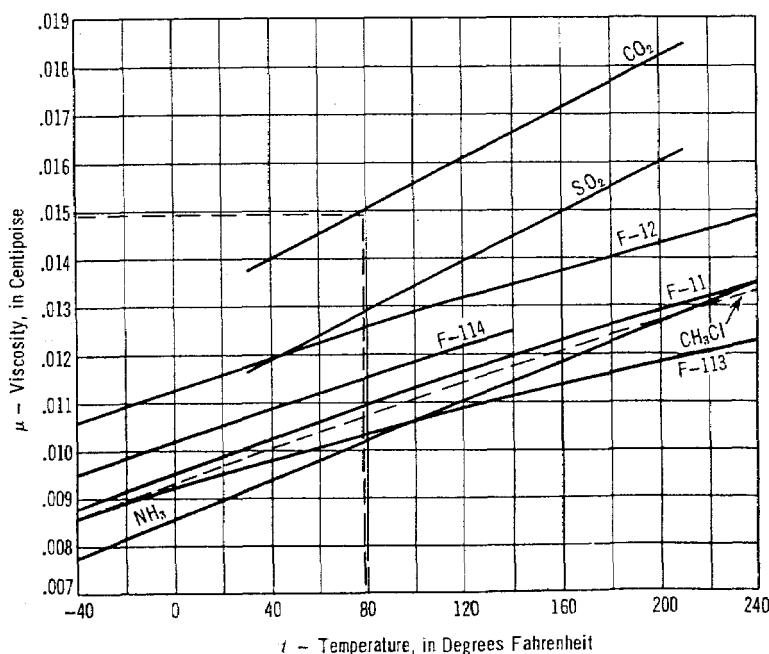
**Upper chart example:** The viscosity of sulphur dioxide gas (SO<sub>2</sub>) at 200 F is 0.016 centipoise.

**Lower chart example:** The viscosity of carbon dioxide gas (CO<sub>2</sub>) at about 80 F is 0.015 centipoise.

Viscosity of Various Gases



Viscosity of Refrigerant Vapors<sup>11</sup>  
(saturated and superheated vapors)



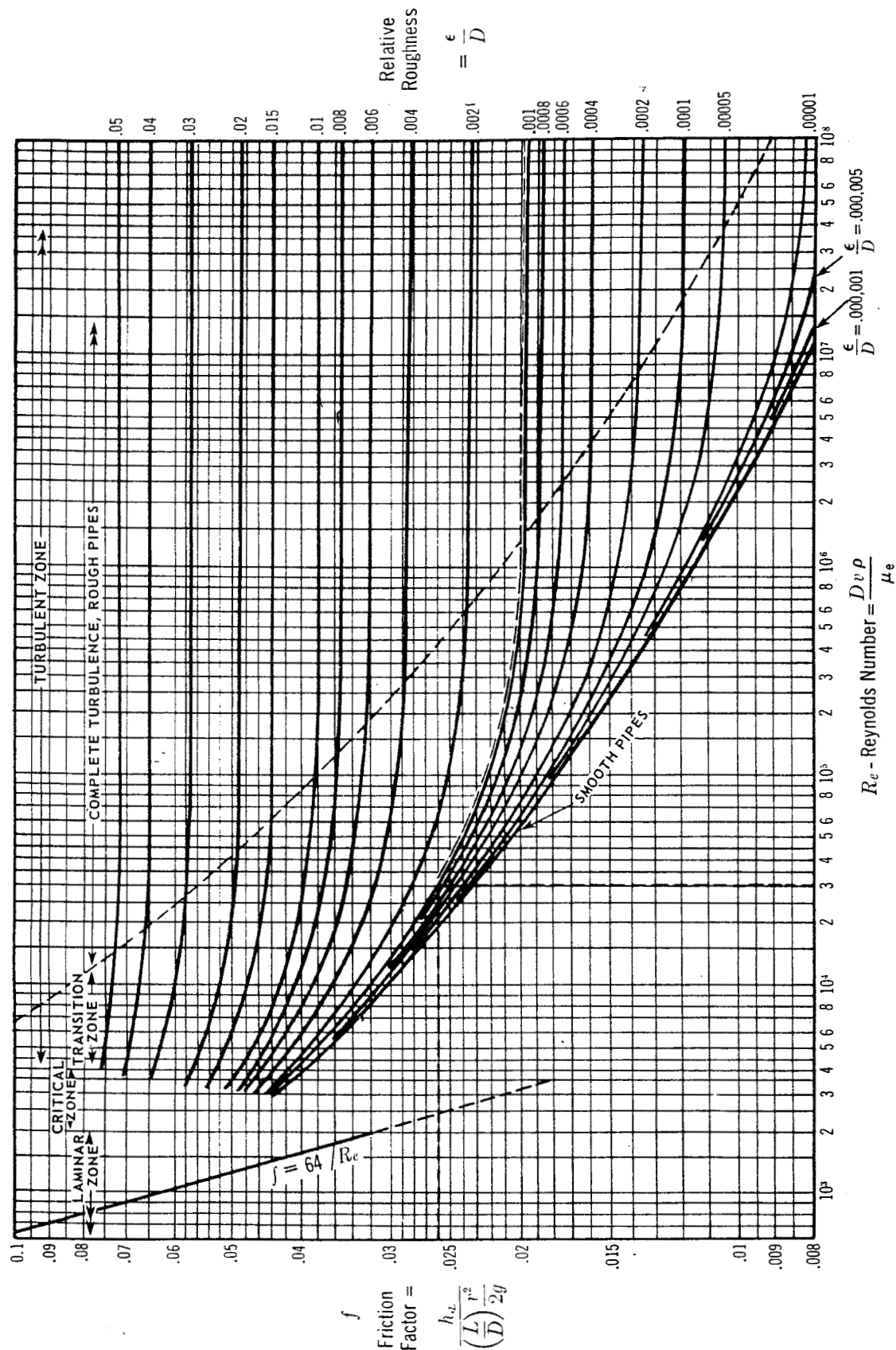
Physical Properties of Gases<sup>13</sup> $c_p$  = specific heat at constant pressure $c_v$  = specific heat at constant volume

Name of Gas	Chemical Formula or Symbol	Approx. Molecular Weight M	Weight Density, Pounds per Cubic Foot* $\rho$	Specific Gravity Relative To Air $S_g$	Individual Gas Constant R	Specific Heat Per Pound at Room Temperature		Heat Capacity Per Cubic Foot at Atmospheric Pressure and 68 F		k equal to $c_p/c_v$
						$c_p$	$c_v$	$c_p$	$c_v$	
Acetylene	$C_2H_2$	26.0	.06754	.897	59.4	.350	.2737	.0236	.0185	1.28
Air	—	29.0	.07528	1.000	53.3	.241	.1725	.0181	.0130	1.40
Ammonia	$NH_3$	17.0	.04420	.587	90.8	.523	.4064	.0231	.0179	1.29
Argon	A	40.0	.1037	1.377	38.7	.124	.0743	.0129	.0077	1.67
Carbon Dioxide	$CO_2$	44.0	.1142	1.516	35.1	.205	.1599	.0234	.0183	1.28
Carbon Monoxide	CO	28.0	.07269	.965	55.2	.243	.1721	.0177	.0125	1.41
Ethylene	$C_2H_4$	28.0	.0728	.967	55.1	.40	.3292	.0291	.0240	1.22
Helium	He	4.0	.01039	.138	386.	1.25	.754	.0130	.0078	1.66
Hydrochloric Acid	HCl	36.5	.09460	1.256	42.4	.191	.1365	.0181	.0129	1.40
Hydrogen	$H_2$	2.0	.005234	.0695	767.	3.42	2.435	.0179	.0127	1.40
Methane	$CH_4$	16.0	.04163	.553	96.4	.593	.4692	.0247	.0195	1.26
Methyl Chloride	$CH_3Cl$	50.5	.1309	1.738	30.6	.24	.2006	.0314	.0263	1.20
Nitrogen	$N_2$	28.0	.07274	.966	55.2	.247	.1761	.0179	.0128	1.40
Nitric Oxide	NO	30.0	.07788	1.034	51.5	.231	.1648	.0180	.0128	1.40
Nitrous Oxide	$N_2O$	44.0	.1143	1.518	35.1	.221	.1759	.0253	.0201	1.26
Oxygen	$O_2$	32.0	.08305	1.103	48.3	.217	.1549	.0180	.0129	1.40
Sulphur Dioxide	$SO_2$	64.0	.1663	2.208	24.1	.154	.1230	.0256	.0204	1.25

\*Weight density values are at atmospheric pressure and 68 F.  
For values at 60 F, multiply by 1.0154.

Volumetric Composition and Specific Gravity of Gaseous Fuels<sup>13</sup>

Type of Gas	Chemical Composition Percent by Volume								Specific Gravity Relative to Air $S_g$	
	Hydro- gen	Carbon Mon- oxide	Paraffin Hydrocarbons		Illuminants		Oxy- gen	Nitro- gen		Carbon Diox- ide
			Meth- ane	Eth- ane	Ethyl- ene	Ben- zene				
Natural Gas, Pittsburgh	...	...	83.4	15.8	...	...	...	0.8	...	0.61
Producer Gas from Bituminous Coal	14.0	27.0	3.0	...	...	...	0.6	50.9	4.5	0.86
Blast Furnace Gas	1.0	27.5	...	...	...	...	...	60.0	11.5	1.02
Blue Water Gas from Coke	47.3	37.0	1.3	...	...	...	0.7	8.3	5.4	0.57
Carbureted Water Gas	40.5	34.0	10.2	...	6.1	2.8	0.5	2.9	3.0	0.63
Coal Gas (Cont. Vertical Retorts)	54.5	10.9	24.2	...	1.5	1.3	0.2	4.4	3.0	0.42
Coke-Oven Gas	46.5	6.3	32.1	...	3.5	0.5	0.8	8.1	2.2	0.44
Refinery Oil Gas (Vapor Phase)	13.1	1.2	23.3	21.7	39.6	...	1.0	...	0.1	0.89
Oil Gas, Pacific Coast	48.6	12.7	26.3	...	2.7	1.1	0.3	3.6	4.7	0.47

Friction Factors for Any Type of Commercial Pipe<sup>18</sup>**Problem:**

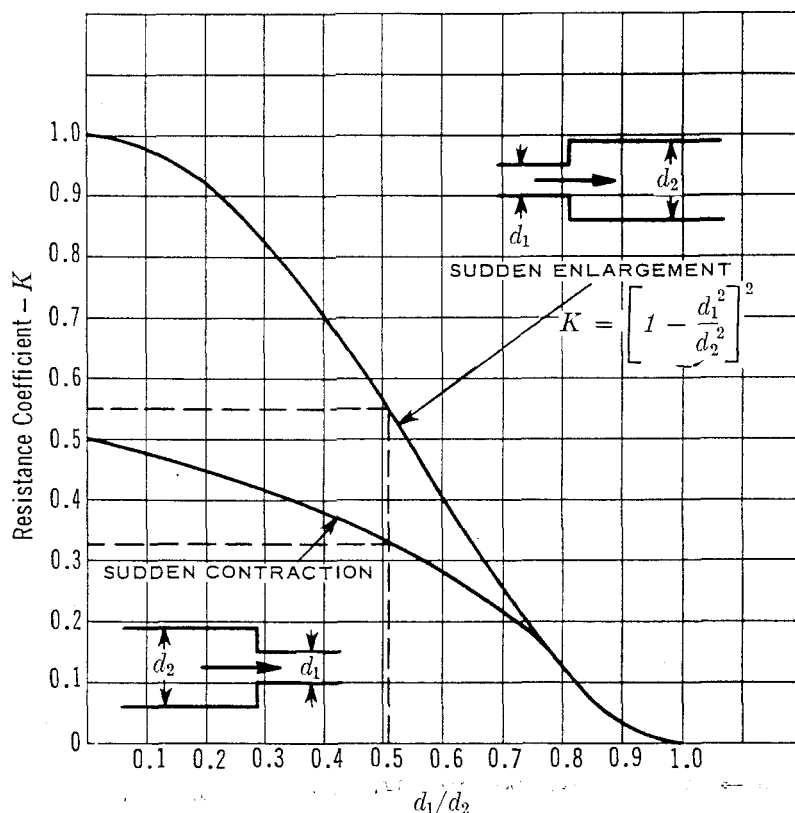
Determine the friction factor for 10-inch cast iron pipe (10.16" I.D.) at a Reynolds number flow of 30,000.

**Solution:** The relative roughness (see page A-23) is 0.001. Then, the friction factor ( $f$ ) equals 0.026.

For other forms of the  $R_e$  equation, see page 3-2.

Data extracted from *Friction Factors for Pipe Flow* by L. F. Moody, with permission of the publisher, The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

## Resistance in Pipe

Resistance Due to Sudden Enlargements and Contractions<sup>20</sup>

**Sudden enlargement:** The resistance coefficient  $K$  for a sudden enlargement from 6-inch Schedule 40 pipe to 12-inch Schedule 40 pipe is 0.55, based on the 6-inch pipe size.

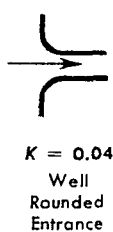
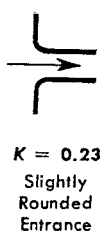
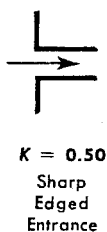
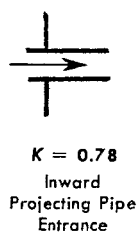
$$\frac{d_1}{d_2} = \frac{6.065}{11.938} = 0.51$$

**Sudden contraction:** The resistance coefficient  $K$  for a sudden contraction from 12-inch Schedule 40 pipe to 6-inch Schedule 40 pipe is 0.33, based on the 6-inch pipe size.

$$\frac{d_1}{d_2} = \frac{6.065}{11.938} = 0.51$$

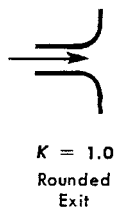
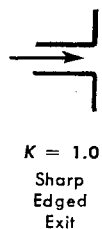
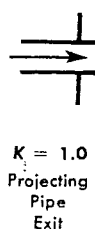
*Note:* The values for the resistance coefficient,  $K$ , are based on velocity in the small pipe. To determine  $K$  values in terms of the greater diameter, multiply the chart values by  $(d_2/d_1)^4$ .

## Resistance Due to Pipe Entrance and Exit



**Problem:** Determine the total resistance coefficient for a pipe one diameter long having a sharp edged entrance and a sharp edged exit.

**Solution:** The resistance of pipe one diameter long is small and can be neglected ( $K = f L/D$ ).



From the diagrams, note:

Resistance for a sharp edged entrance = 0.5

Resistance for a sharp edged exit = 1.0

Then,  
the total resistance,  $K$ , for the pipe = 1.5

## Resistance of Bends

### Resistance of 90 Degree Bends<sup>21</sup>

The chart at the right shows the resistance of 90 degree bends to the flow of fluids in terms of equivalent lengths of straight pipe. Resistance of bends greater than 90 degrees is found using the formula:

$$\frac{L}{D} = R_t + (n - 1) \left( R_t + \frac{R_b}{2} \right)$$

$n$  = total number of 90° bends in coil

$R_t$  = total resistance due to one 90° bend, in  $L/D$

$R_t$  = resistance due to length of one 90° bend, in  $L/D$

$R_b$  = bend resistance due to one 90° bend, in  $L/D$

**Problem:** Determine the equivalent lengths in pipe diameters of a 90 degree bend and a 270 degree bend having a relative radius of 12.

**Solution:** Referring to the "Total Resistance" curve, the equivalent length for a 90 degree bend is 34.5 pipe diameters.

The equivalent length of a 270 degree bend is:

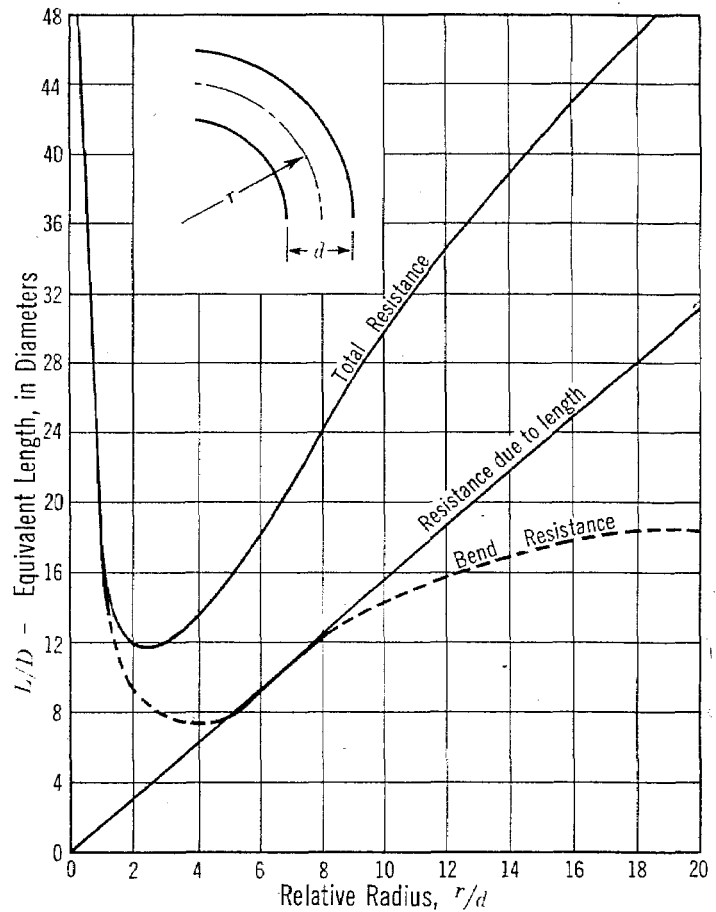
$$L/D = 34.5 + (3 - 1) [18.7 + (15.8 \div 2)]$$

$$L/D = 87.7 \text{ pipe diameters}$$

**Note:** This loss is less than the sum of losses through three 90 degree bends separated by tangents. For "resistance of bends theory", see page 2-12.

Chart for Resistance of 90 Degree Bends

From *Pressure Losses for Fluid Flow in 90 Degree Pipe Bends* by K. H. Beij. Courtesy of *Journal of Research of National Bureau of Standards*, Vol. 21, July, 1938.



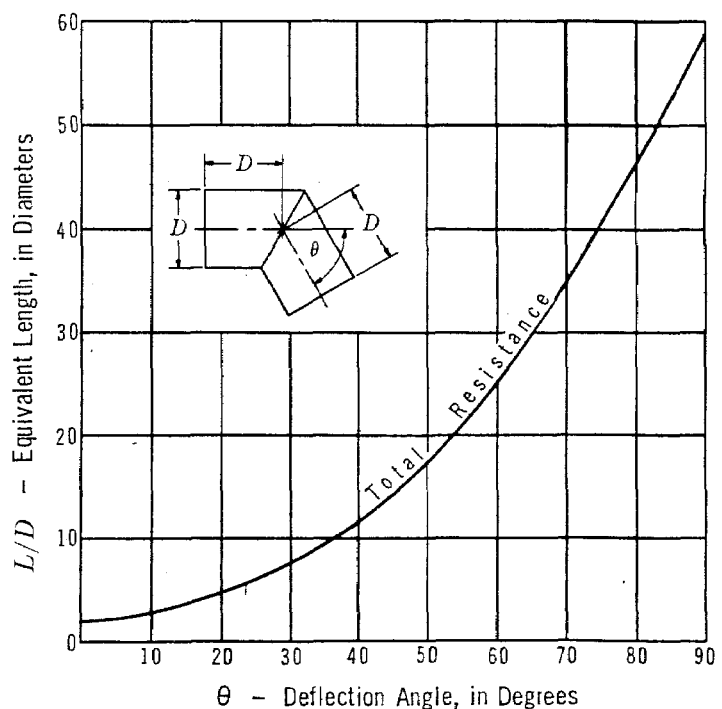
### Resistance of Miter Bends<sup>4</sup>

The chart at the lower right shows the resistance of miter bends to the flow of fluids. The chart is based on data published by the American Society of Mechanical Engineers (ASME).

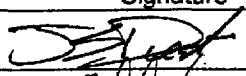



**Problem:** Determine the equivalent length in pipe diameters of a 40 degree miter bend.

**Solution:** Referring to the "Total Resistance" curve in the chart, the equivalent length is 12 pipe diameters.

Chart for  
Resistance of  
Miter Bends





EDF Title: Project Stormwater/Drainage Design				
Project No.: 2000-096		Project Title: OU 1-10, Group 3		
<p>Problem Statement: Prior to start of soil removal at TSF-26, stormwater from the SE corner of TAN was routed through TSF-26 via an open ditch to a stormwater retention pond. When the TSF-26 cleanup started, the inlet to TSF-26 was plugged and flow to the retention pond was cut off. The purpose of this design is to re-establish flow to the retention pond while preventing surface water and sediment from TSF-26 from leaving the TSF-26 site. This design also provides a temporary stormwater control plan during construction.</p>				
<p>Summary of Conclusions: A 2' diameter CPE pipe with watertight joints will be placed across TSF-26 at a slope of .00125 ft/ft. The site will be graded as shown in the attached drawings to provide sufficient volume to retain the design storm. The site shall be graded as shown in sheet 5 of the package for stormwater control during construction.</p>				
Review and Approval Signatures:				
		Printed Name	Signature	Date
Prepared by:		Shaun Dustin		10-2-03
Checked by:		KEVIN SHABER		12/3/03
Approval:		GARY MECHAM		12/3/03
Distribution:				
Professional Engineer's Stamp (if required)				
				

## ENGINEERING DESIGN FILE

EDF Title Project Stormwater/Drainage Design		EDF- 096-016	
Project No.: 2000-096		Rev No.:	
Project Title: OU 1-10, Group 3		Page	2 of 2
Prepared by:	Date:	Checked by:	Date:

**Problem Statement:** Prior to start of soil removal at TSF-26, stormwater from the SE corner of TAN was routed through TSF-26 via an open ditch to a stormwater retention pond. When the TSF-26 cleanup started, the inlet to TSF-26 was plugged and flow to the retention pond was cut off. The purpose of this design is to re-establish flow to the retention pond while preventing surface water and sediment from TSF-26 from leaving the TSF-26 site. This design also provides a temporary stormwater control plan during construction.

**Design Basis:** Stormwater must be accounted for in the site design at TSF-26. The design storm is the 25-yr, 6 hr storm generating 1.4 inches of water over the area in question. The water draining through the site will be isolated from runoff generated on site by piping the water draining across the site along the flowline of the existing ditch. Permanent stormwater control for the site will be accomplished by grading the site to permit retention of all precipitation for the design storm. Stormwater generated on site during construction will be retained onsite in constructed ponds sized for the full 25-yr, 6-hr storm. For control of stormwater during construction, the 25-yr, 6-hr storm will be used but infiltration will be considered.

**Assumptions:** See calculation sheets

**References:** DOE-ID A&E Standards, Civil Design, Section 0200.2.8. Water Resources Engineering, Linsley, Et Al, McGraw Hill, 1992. Hydrology, Water Quantity and Quality Control, M wanielista, Et Al, John Wiley and Sons, 1997. Manufacturer data as incorporated in EDF. Drawings C-7, C-8, C-9.

**Calculations / Analysis:** See attached calculation sheets



A New Type of Engineering Company  
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM 2A Stormwater

SHEET NO. 1 OF 5

CALCULATED BY S. Ductin DATE 7/7/03

CHECKED BY DATE

SCALE

Problem Statement: The TSF-26 area served as the primary conduit for stormwater draining to the retention pond west of the TSF-26 site. The flow path was blocked at some point in the past, and there is currently no way for stormwater to get to the retention pond. Further, the stormwater runoff generated by the TSF-26 should be retained within the TSF-26 area. The purposes of this design are:

- 1) To restore the flow path to the retention pond
- 2) To demonstrate that the final grading plan provides adequate retention volume for stormwater generated on-site

### Part I: Restore Flow to Existing Retention Pond

The existing storm runoff drains down from the upper TAN area where it is detained in a large, unused area, east of the TSF-26 area (7). The water then drains to an irregular ditch (6), and a 2' Ø CMP culvert (5). The culvert was plugged at some point in the past to prevent runoff from entering the TSF-26 area where an open ditch, in addition to routing the off-site flow through TSF-26, collected surface water drainage from TSF-26. This design will separate the waste streams.

The ditch across TSF-26 will be replaced with a silt-tight gasfitted pipe to prevent sediment or surface water intrusion. TSF-26 itself will be regraded to keep surface water away from the new pipe.

Pipe size selection: The area currently used for detention (7) has the effect of attenuating flows significantly. In the years since pipe (5) has been plugged, no the lack of an outlet has not had so (7) has not had any deleterious effects on the area. No flooding or significant ponding has been observed in (7), leading to the conclusion that the pipe in (4) is an overflow for extreme events. The pipe in (4) does need to be sized to ensure that it provides the same flow capacity as the upstream pipe, and maintain the minimum pipe slope required for self-cleaning of sediment.

Analysis Techniques- Manning's Equation, pipe full, slopes as measured.

For existing pipe the following conditions apply:

$$\begin{aligned} & 2' \text{ Ø} \\ & \text{CMP (Poor condition), Manning's } N = 0.022 \\ & L = 111 \text{ ft} \\ & \Delta Z = 0.48 \text{ ft} \end{aligned}$$

$$V = \frac{1.49}{0.022} (R_h)^{2/3} S^{1/2}$$

$$R_h = \frac{A}{P_w} = \frac{\pi d^2/4}{\pi d} = \frac{d}{4}$$

$$V = \frac{1.49}{0.022} (0.5)^{2/3} \left(\frac{.48}{111}\right)^{1/2} = 2.8 \text{ ft/s}$$

$$Q = VA = \frac{2.8 \text{ ft}}{s} \left(\frac{\pi \cdot 2^2}{4}\right) = 8.8 \text{ ft}^3/\text{s}$$



A New Type of Engineering Company  
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PN2A Stormwater

SHEET NO. 2 OF 15

CALCULATED BY STW DATE 7/9/03

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

For proposed pipe, solve for N given the following:

Use CPE (Corrugated Polyethylene)

Use  $Q = 8.8$

Use  $S = 0.54/400ft = 0.00125$  (Max slope allowed by site)

Use  $D = 24in$ ,  $\therefore A = 3.14ft^2$ ,  $P = 6.28ft$ ,  $R_h = 0.5$

$$8.8 = VA = 3.14 \left( \frac{1.49}{N} \right) (0.5)^{2/3} (0.00125)^{1/2}$$

From equation solver,  $n = 0.012$ . Smooth wall CPE N values are 0.010-0.012.

Using an N value of 0.011,  $Q_{newpipe} > Q_{upstream}$ .

$\therefore$  the use of 2'  $\phi$

CPE @  $S = 0.125ft/100ft$  provides adequate capacity.

Use smooth wall CPE Pipe; ADS N-12 IB WT or Hancor Blue Seal.  
Specifications for both are attached.

The minimum slope for ~~FTF~~ 24"  $\phi$  pipe recommended by "Recommended Standards for Wastewater Facilities, 1997 ed." is 0.08 ft/100 ft. Design slope is 0.125 ft/100 ft  $\therefore$  Slope OK

### Cover Over Pipe

Per Mta recommendations, provide 12" min cover over pipe in trafficked areas.

### Specifications

See attached

### Summary, Part I

Supply 2'  $\phi$  CPE pipe, watertight <sup>gasketed bell & spigot</sup> joints, capable of supporting HS 25 load with 1' compacted cover. Smooth inside wall. Manning's "n" value for design not more than 0.012. Use ASTM F-1417 or ASTM C969 to test watertightness. Gasket shall meet ASTM F477. Pipe shall be virgin HDPE meeting the requirement of ASTM D 3350. Install at min slope of 0.125 ft/100 ft.



A New Type of Engineering Company  
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

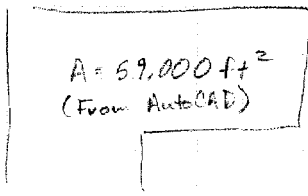
JOB PNCA Stormwater  
SHEET NO. 3 OF 45  
CALCULATED BY ST. J. J. DATE 9/10/03  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_  
SCALE \_\_\_\_\_

## Part 2: ON-SITE STORMWATER RETENTION

Objective: Demonstrate that final site grading provides enough volume to capture total runoff generated in the event of the DOE-ID INEEL site specific local precipitation std. for a 25 yr, 6hr storm, 1.4" total

Assumptions: Frozen ground, zero infiltration

### TOTAL VOLUME OF RAINFALL



A = Area of TSF-26 inside fence

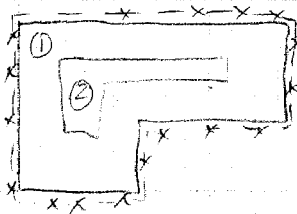
$$V = A \cdot D$$

$$= 59,000 \text{ ft}^2 \cdot \frac{1.4 \text{ in}}{12 \text{ in/ft}}$$

$$V = 6883.3$$

$$V_R = 6900 \text{ ft}^3$$

### TOTAL VOLUME OF GRADED AREA (See attached sheet for grading plan)



A<sub>1</sub> = Area inside new 4780.0 contour

$$A_{1,2} = 56,000$$

$$A_2 = 11,400$$

$$A_1 = 44,600$$



A New Type of Engineering Company

501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM2A stormwater

SHEET NO. 11

OF 15

CALCULATED BY SDue

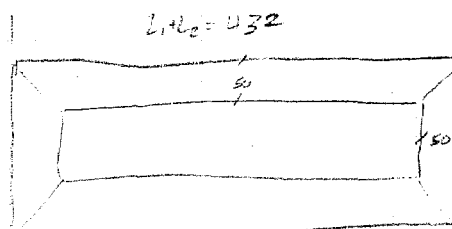
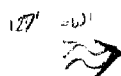
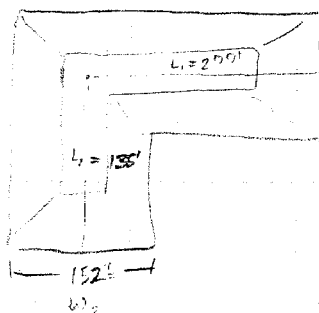
DATE 7/10/03

CHECKED BY \_\_\_\_\_

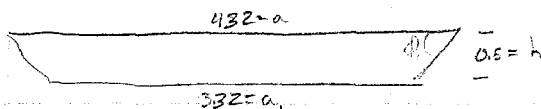
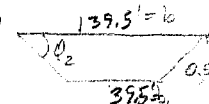
DATE \_\_\_\_\_

SCALE \_\_\_\_\_

For Area ② Graded flat:



$$\frac{w_1 + w_2}{2} = 139.5'$$



$$V = \frac{h}{6} (A_1 + (a + a_1)(b + b_1) + A_2)$$

$$V = \frac{0.5}{6} [(56000) + (332 + 432)(139.5 + 39.5) + (11,400)]$$

$$V = (204,156) \div 2$$

$$V = 17,000$$

### CONCLUSION:

$V_R = 7,600 < V = 17,000$ ;  $\therefore$  There is sufficient volume for on-site retention of the 25-yr-6hr storm with no infiltration with the above grading plan.



A New Type of Engineering Company  
501 West Broadway, Suite 200 Idaho Falls, ID 83402  
(208) 529-5337

JOB PM 2 A Stormwater

SHEET NO. 5 OF 5

CALCULATED BY S. Rustin DATE 7/14/03

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SCALE \_\_\_\_\_

### Temporary Stormwater Control, Construction Case

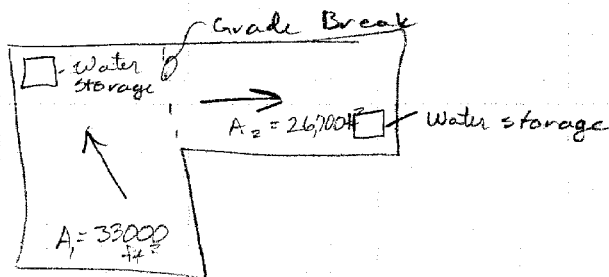
Assumptions: Work will take place when ground is not frozen

Total rainfall: 1.4"

Runoff coefficient: 0.3 (use RR yard coefficient from P 206, Wanielista)

Total runoff:  $\text{Area} \cdot 0.3 \cdot 1.4 \frac{\text{in}}{12 \text{ in/ft}} = A \cdot 0.035$

Site will be graded as shown:



$$V_1 = (33000) \cdot 0.035$$

$$V_1 = 1155 \text{ ft}^3$$

$$V_2 = 26,700 \cdot 0.035$$

$$V_2 = 935 \text{ ft}^3$$

Conclusion: Require contractor to provide 2 ponds sized as shown and to grade site as shown to drain to ponds

- ① - TSF-26
- ② - Stormwater Retention
- ③ - 2'  $\phi$  culvert (CMP)
- ④ - Proposed 2'  $\phi$  CPE culvert
- ⑤ - Existing 2'  $\phi$  CMP culvert
- ⑥ - Ditch
- ⑦ - Current Stormwater detention.





[illegible]

A B C D E F G H J K L M N O P

REV	DATE	DESCRIPTION

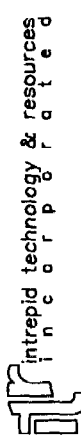
NOTES

- 1) BEDDING: SUITABLE MATERIAL SHALL BE CLASS I, II, OR III AND INSTALLED PER ASTM D2321, CURRENT EDITION. MINIMUM BEDDING THICKNESS SHALL BE 4".
- 2) HAUNCHING AND INITIAL BACKFILL: SUITABLE MATERIAL SHALL BE CLASS I, II, OR III AND INSTALLED PER ASTM D2321, LATEST EDITION.
- 3) MINIMUM TRENCH WIDTH SHALL BE 48".
- 4) MINIMUM COVER OVER TRENCH SHALL BE 12". FOR CONSTRUCTION OPERATIONS PRIOR TO SITE GRADING, CONTRACTOR SHALL PROVIDE MIN 24" COMPACTED FILL OVER PIPE. CONTRACTOR SHALL BE RESPONSIBLE FOR REMOVAL AND REPLACEMENT OF ALL PIPE MATERIALS DAMAGED BY CONSTRUCTION OPERATIONS PRIOR TO FINAL COMPLETION.
- 5) CPEP: CORRUGATED POLYETHYLENE PIPE
- 6) ALL OPEN DITCHES SHALL BE GRADED AT 2H:1V TO MATCH EXISTING GROUND SURFACE ELEVATIONS.
- 7) GRADE GROUND SURFACE AROUND OPEN CHANNELS TO DRAIN INTO CHANNELS.
- 8) PROVIDE CONSTANT SLOPE BETWEEN EXISTING AND NEW PIPE INVERTS. INSTALL NEW CULVERTS TO ELEVATIONS SHOWN IN SHEET C-8.

SCALE: AS NOTED

90% DESIGN

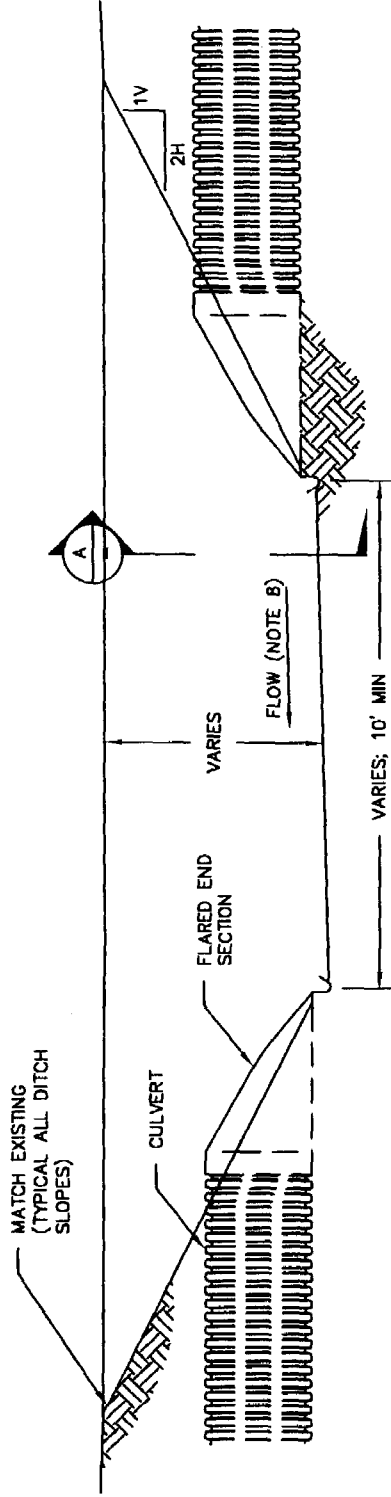
OU 1-10 TSF-26  
DETAILS,  
STORMWATER



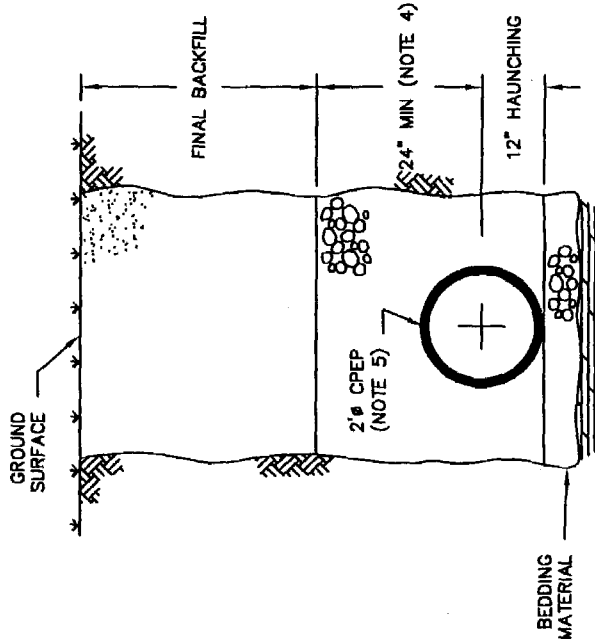
501 W. BROADWAY, SUITE 200, IDAHO FALLS, ID 83402  
(208)528-5337 FAX: (208)528-1014

D-3

DRAWN: S. DUSTIN	TASK ORDER NUMBER 2000-096
DESIGNED:	QA LEVEL: D
CHECKED:	CG
APPROVED:	DRAWING NUMBER
CADD FILE: DWG	REV: A

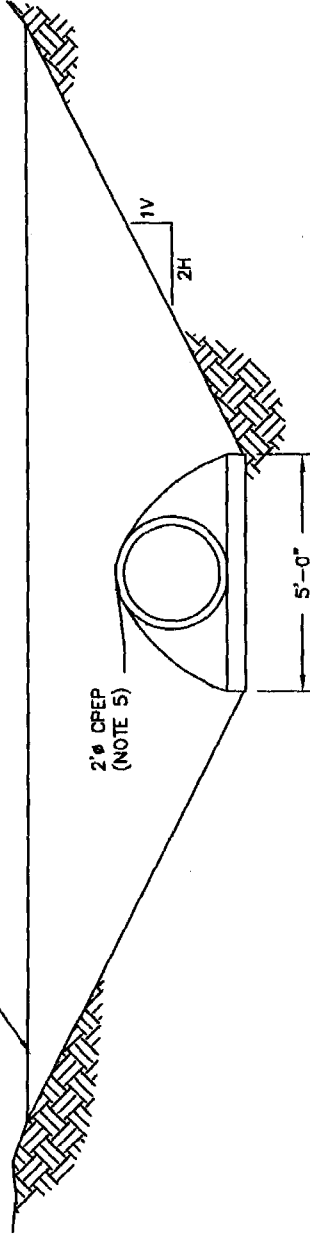


1  
C-8  
DETAIL  
STORM DRAIN TRANSITION DITCH  
AND SURFACE WATER COLLECTION  
NTS



A  
C-8  
SECTION  
STORM DRAIN TRENCH  
CROSS SECTION  
NTS

MATCH EXISTING  
(TYPICAL ALL DITCH  
SLOPES)



A  
SECTION  
STORM DRAIN  
OPEN CHANNEL  
NTS

A B C D E F G H J K L M N O P

REV	DATE	DESCRIPTION	APPROVED

NOTES

- 1) GRADE SITE TO DRAIN AS SHOWN. PLACE 6" TOPSOIL PREPARATORY TO REVEGETATION. MATCH EXISTING ELEVATIONS AT FENCELINE. GRADE FLAT WITHIN BOUNDARY DESIGNATED BY COORDINATES AS SHOWN.
- 2) FERTILIZE AND SEED PER THE SPECIFICATIONS.
- 3) REMOVE TRAILERS AND SITE UTILITIES. REMOVE WASHDOWN PAD. CLEAN UP SITE AND RESTORE AREAS AFFECTED BY CONSTRUCTION.

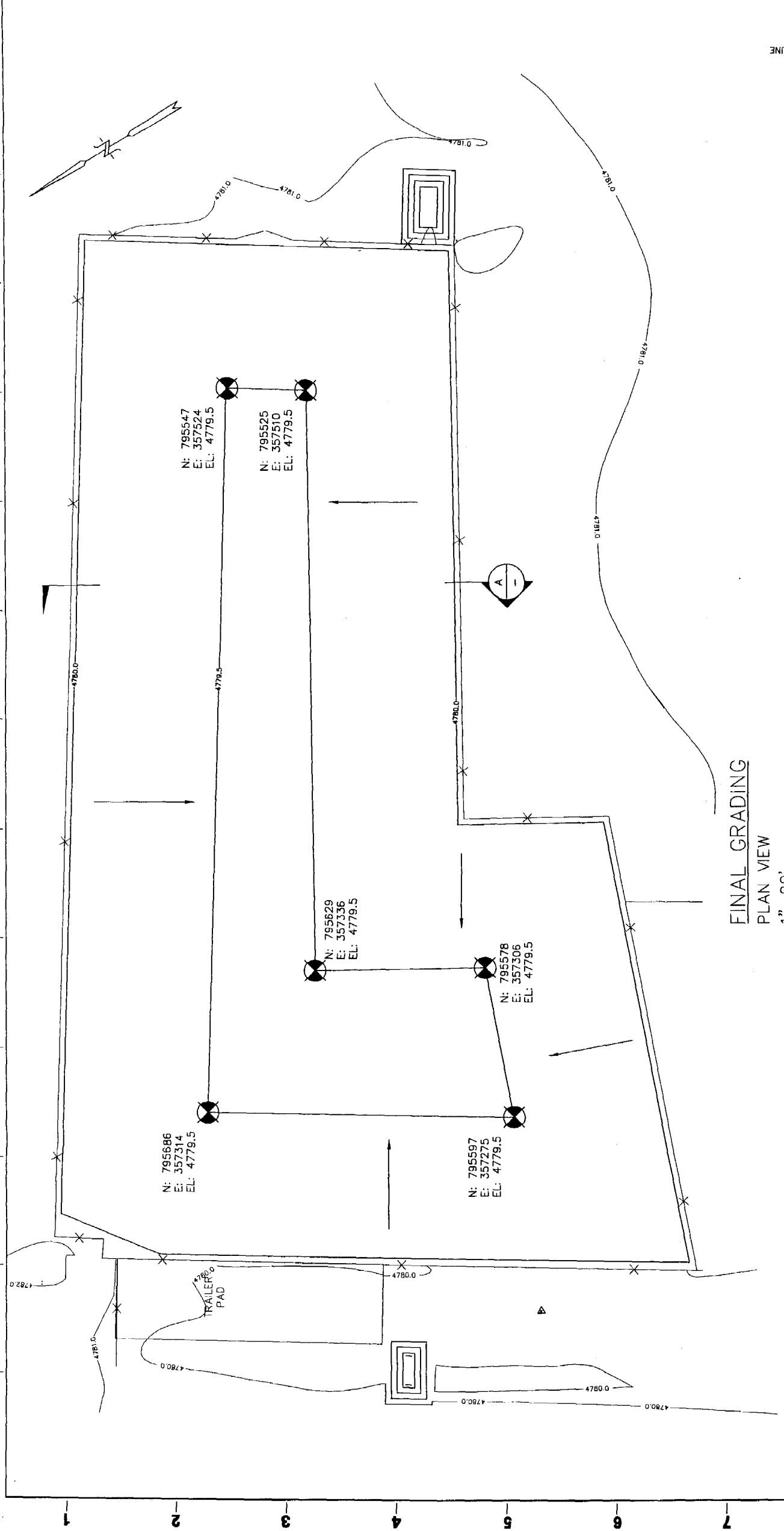
SCALE: AS NOTED

90% DESIGN  
OU 1-10 TSF-26  
FINAL  
GRADING PLAN

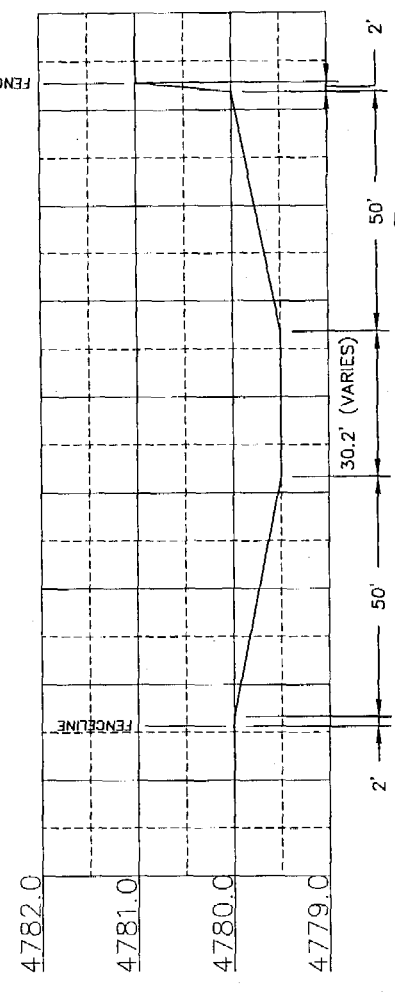
**intrepid** technology & resources  
inc or p r a t e d  
501 W. BROADWAY, SUITE 200, IDAHO FALLS, ID 83402  
(208)528-5337 FAX: (208)528-1014

C-8

DRAWN: S. DUSTIN	TASK ORDER NUMBER 2000-096
DESIGNED:	QA LEVEL: CC
CHECKED:	DWG SIZE: D
APPROVED:	DRAWING NUMBER
CADD FILE: DWG	REV: A

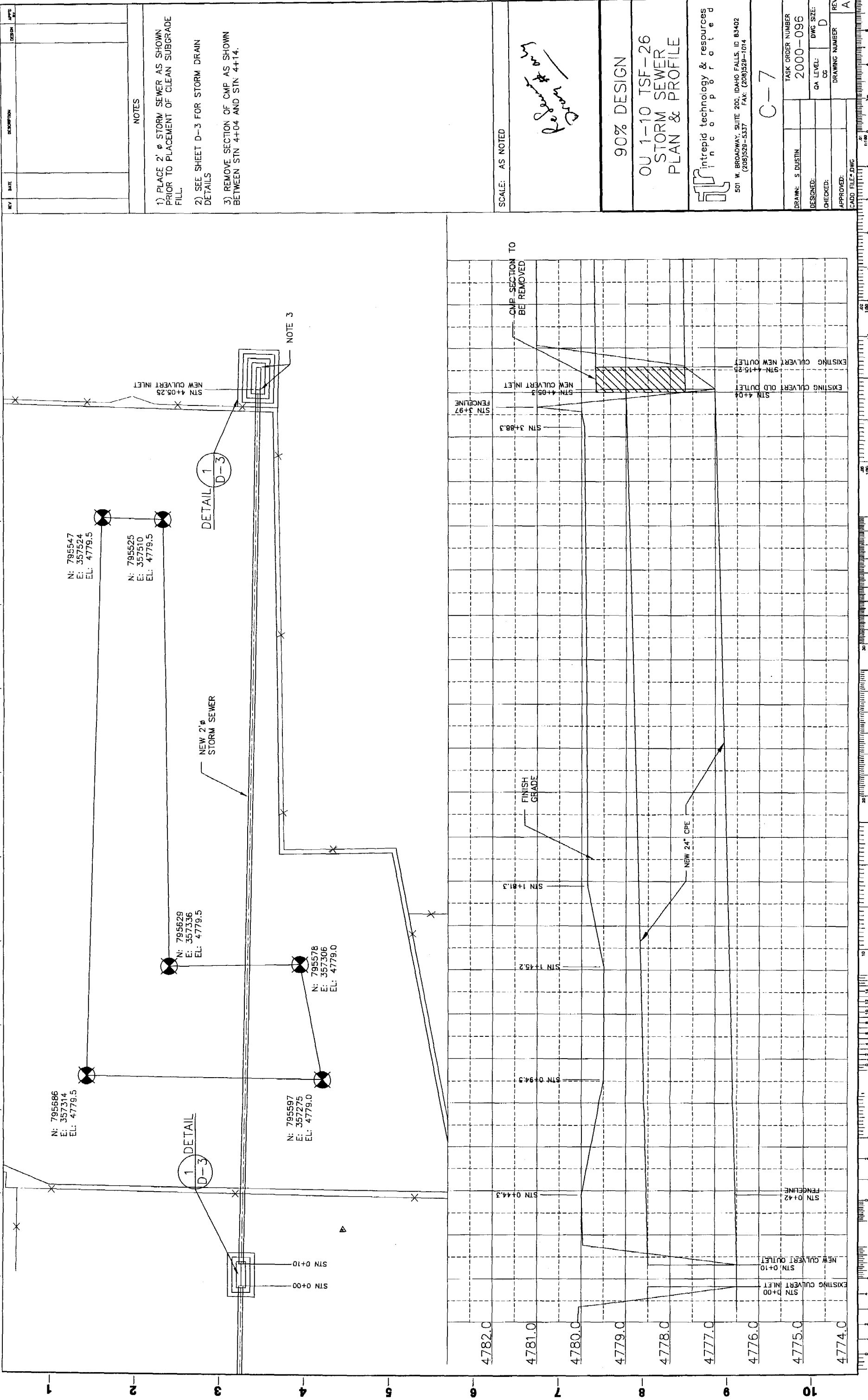


FINAL GRADING  
PLAN VIEW  
1"=20'



SECTION  
A-A  
REPRESENTATIVE CROSS SECTION  
SCALE: 1"=20' H; 1"=1' V

A B C D E F G H J K L M N O P



NOTES

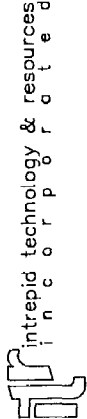
- 1) PLACE 2' Ø STORM SEWER AS SHOWN PRIOR TO PLACEMENT OF CLEAN SUBGRADE FILL.
- 2) SEE SHEET D-3 FOR STORM DRAIN DETAILS
- 3) REMOVE SECTION OF CMP AS SHOWN BETWEEN STN 4+04 AND STN 4+14.

SCALE: AS NOTED

*Design & Survey*

90% DESIGN

OU 1-10 TSF-26  
STORM SEWER  
PLAN & PROFILE



501 W. BROADWAY, SUITE 203, IDAHO FALLS, ID 83402  
(208)528-5337 FAX: (208)528-1014

C-7

DRAWN: S. DUSTIN	TASK ORDER NUMBER
DESIGNED:	2000-096
CHECKED:	QA LEVEL: D
APPROVED:	DWG SIZE: D
CADD FILE: DWG	DRAWING NUMBER
REV	A



# BLUE SEAL™ PIPE, WATERTIGHT PERFORMANCE



Bury it and forget it.

## THE PERFORMANCE YOU EXPECT. THE INNOVATIONS YOU NEED.

With over a century of experience, we're experts when it comes to drainage, providing innovative solutions for all kinds of applications. Our HDPE pipe delivers superior value while providing physical strength and structural design that just cannot be matched by metal or concrete.

Hancor's new patent pending, highly engineered composite pipe joining system, a unique combination of three different materials, is being described as the best watertight solution on the market.

BLUE SEAL is a gravity flow, watertight pipe ideal for storm sewers, detention systems, and cross, slope or edge drains. Other applications include golf courses, sports playing fields, or parking lot drainage, as well as irrigation ditch enclosures.

Available in a complete range of sizes from 12" - 60" (300 - 1500mm) diameters, this Hancor exclusive solution is 3rd party verified to meet 10.8 psi pressure and vacuum testing requirements and EPA Phase II Best Management Practices. Once again, Hancor leads the way in offering a 60" corrugated HDPE verified watertight joining system.

The unique feature that sets this system apart from any other is a highly engineered integral bell-and-spigot system that utilizes expanding structural foam technology for gasket support. This revolutionary coupling system maintains bell dimension after pressurization providing uniform tolerances to ensure the highest consistent performance not found in the corrugated pipe industry. Hancor's multicomposite reinforced bell design is easily recognized by its blue product identification wrap.

## 5 YEAR WARRANTY

BLUE SEAL, Hancor's new highly engineered composite pipe joining system is backed by an industry exclusive 5 year limited warranty.

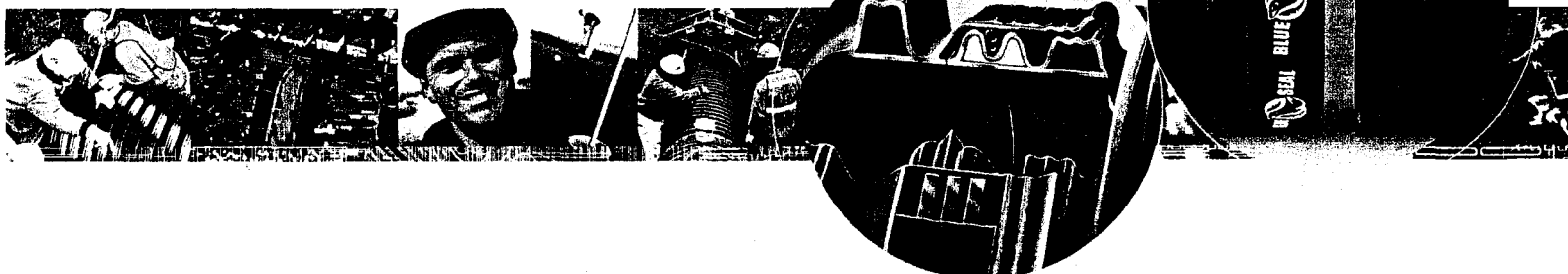
## FEATURES

- Meets 10.8 psi water pressure and vacuum testing requirements.
- Addresses EPA Phase II Best Management Practices for long-term service reliability.
- Lightweight, high strength composite system requires less labor time for faster installations and reduced costs.
- Bell and gasket corrugation reinforcement provides uniform support not found in the corrugated polyethylene pipe industry.
- Fast bell-and-spigot joint assembly with unsurpassed structural integrity.
- HDPE pipe provides superior resistance to prevent rusting, deterioration or crumbling.

## BENEFITS

- Provides a visible commitment to better water quality, minimizing environmental impact.
- Prevents the contamination of soil and local waters from harmful substances such as sediment from construction runoff, lawn care products or automobile emissions.
- Avoids possible joint infiltration of sands and fines resulting in sinkholes and differential settlement to adjacent structures.
- Reduces the risk of blockage caused by vegetation infiltration into joints.
- Reduces soil migration.
- Exclusive 5 year limited warranty for superior value.

**Hancor Service:** Hancor representatives and engineers are committed to providing you with the answers to all your questions, including specifications, installation, backfill recommendations and more.





## BLUE SEAL™ PIPE SPECIFICATIONS

Diameter: 12" - 60" (300 - 1500mm)

Length:

- 20' (6m) for 12" - 30" (300 - 750mm) diameter pipe.
- 20.5' (6.24m) for 36" - 60" (900 - 1500mm) diameter pipe.

Specifications: AASHTO M294, Type S and AASHTO MP7, Type S.

Joint Performance: Watertight

Joining System: Bell-and-spigot

Gasket: Polyisoprene meeting ASTM F477

Fittings and Accessories: Hancor offers a full line of fittings for all diameters of Hancor pipe.

## SCOPE

This specification describes 12" - 60" (300 - 1500mm) Hancor BLUE SEAL pipe for use in gravity flow applications.

## PIPE REQUIREMENTS

BLUE SEAL pipe shall have a smooth interior and annular exterior corrugations.

- 12" - 48" (300 - 1200mm) shall meet AASHTO M294, Type S.
- 60" (1500mm) meets AASHTO MP7, Type S.
- Manning's "n" value for use in design shall be no less than 0.010.

## MATERIAL PROPERTIES

Pipe and fitting material shall be high-density polyethylene meeting ASTM D3350 minimum cell classification 335400C. The pipe material shall be Hancor Resin 8™, which is a high stress crack resistant material evaluated using the single point notched constant tensile load (SP-NCTL) test. Average SP-NCTL test specimens must exceed 24 hrs. with no test result less than 17 hrs. The closed cell structural foam core must have a free rise density no less than

3 lbs/ft<sup>3</sup> and compressive strength no less than 20 lbs/in<sup>2</sup>.

## JOINT PERFORMANCE

Pipe shall be joined with the BLUE SEAL™ joint meeting the requirements of AASHTO M294, or AASHTO MP7. 12" - 60" (300 - 1500mm) shall be watertight according to the requirements of ASTM D3212. Gaskets shall be made of polyisoprene, meeting the requirements of ASTM F477 with the addition that the gaskets shall not have any visible cracking when tested according to ASTM D1149 after 72 hours exposure in 50 PPHM ozone at 104° Fahrenheit. Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. 12" - 30" (300 - 750mm) bells shall include a reinforcing rib at the flare OD to assure meeting roundness tolerances and enhance proper joint assembly. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly. 24" - 60" (600 - 1500mm) diameters shall have a reinforced bell-and-spigot, including a bell tolerance device. The bell tolerance device shall be installed by the manufacturer and covered with a protective wrap. The gasket corrugation shall be reinforced with a closed cell structural foam core.

## FITTINGS

Fittings conform to AASHTO M294 or AASHTO MP7. Fabricated fittings are welded at all accessible interior and exterior junctions.

## WATERTIGHT FIELD TEST PERFORMANCE

To assure watertight field performance, verification may be accomplished using ASTM F 1417 or ASTM C 969 test procedures. Appropriate safety precautions must be used when field testing any pipe material.



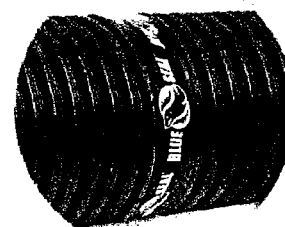
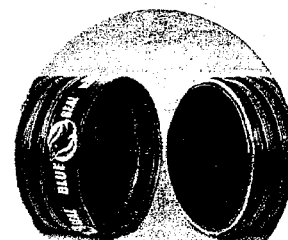
Bury it and forget it.

## INSTALLATION

Installation should be in accordance with ASTM D2321, with the exception that minimum cover in trafficked areas for 12" - 48" (300 - 1200mm) diameters is 1 ft. (0.3m), and for 60" (1500mm) diameters, 1.5 ft. (0.5m).

## QUALITY ASSURANCE

All corrugated polyethylene pipe meeting or exceeding AASHTO M294 or MP7 shall only be provided by manufacturers listed by the Plastic Pipe Institute (PPI) as having met the requirements of the PPI sponsored third-party certification program. All AASHTO M294 and MP7 pipe shall be clearly marked with a certification program mark or logo representing the supplied pipe is in compliance with all applicable standards.



Pipe I.D., in. (mm)	12 (300)	15 (375)	18 (450)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	60 (1500)
Pipe O.D., in. (mm)	14.2 (361)	17.7 (450)	21.5 (546)	28.4 (721)	36.0 (914)	41.4 (1052)	48.0 (1219)	55.0 (1397)	67.3 (1709)
Flare O.D., in. (mm)	15.4 (391)	19.6 (498)	23.9 (607)	29.9 (759)	37.9 (963)	43.6 (1107)	50.8 (1290)	57.4 (1458)	73.7 (1872)
Pitch, in. (mm)	2.0 (51)	2.4 (61)	3.0 (76)	4.0 (102)	4.0 (102)	4.6 (117)	5.8 (147)	5.8 (147)	7.8 (198)
Approx. Weight* lb/20 ft. stick (kg/6m stick)	70 (32)	100 (46)	130 (59)	220 (100)	330 (150)	400 (182)	500 (227)	597 (260)	861 (315)

\*One stick is 20' (6m) for 12"-30" (300-750mm) diameter pipe and 20.5' (6.24m) for 36"-60" (900-1500mm) diameter pipe.

All sales of Hancor product are subject to a limited warranty and purchasers are solely responsible for installation and use of Hancor products and determining whether a product is suited for any specific needs. Please consult a full copy of Hancor's Terms and Conditions for Sale for further details.

## Direct Contact

### Customer Service

888-FOR PIPE (367-7473)

Fax 888-FAX PIPE (329-7473) 24 hours a day

### Application Engineering

For technical questions, call

800-2HANCOR (242-6267), ext. 809

## Electronic Media

### Web Site

Find market- and application-specific information and the latest industry news at our On-Line Pipeline - [www.hancor.com](http://www.hancor.com)

Hancor®, BLUE SEAL™ and Resin 8™ are registered trademarks of Hancor, Inc.  
© 2002 Hancor, Inc. 1900-266  
#1121/0402

## HANCOR BLUE SEAL™ PIPE SPECIFICATIONS

### Scope

This specification describes 12- through 60-inch (300 to 1500 mm) Hancor BLUE SEAL™ pipe for use in gravity flow applications.

### Pipe Requirements

BLUE SEAL™ pipe shall have a smooth interior and annular exterior corrugations.

- 12- through 48-inch (300 to 1200 mm) shall meet AASHTO M294, Type S.
- 60-inch (1500 mm) shall meet AASHTO MP 7, Type S.
- Manning's "n" value for use in design shall not be less than 0.010.

### Joint Performance

Pipe shall be joined with the BLUE SEAL™ joint meeting the requirements of AASHTO M294, or AASHTO MP7.

12- through 60-inch (300 to 1500 mm) shall be watertight according to the requirements of ASTM D3212. Gaskets shall be made of polyisoprene meeting the requirements of ASTM F477 with the addition that the gaskets shall not have any visible cracking when tested according to ASTM D1149 after 72 hour exposure in 50 PPHM ozone at 104°Fahrenheit. Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. 12- through 30-inch (300 to 750 mm) bells shall include a reinforcing rib at the flare O.D. to assure meeting roundness tolerances and enhance proper joint assembly. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.

24- through 60-inch (600 to 1500 mm) diameters shall have a reinforced bell & spigot including a bell tolerance device. The bell tolerance device shall be installed by the manufacture and covered with a protective wrap. The gasket corrugation shall be reinforced with a closed cell structural foam core.

### Watertight Field Test Performance

To assure watertight field performance verification may be accomplished using ASTM F 1417 or ASTM C 969 test procedures. Appropriate safety precautions must be used when field testing any pipe material.

### Fittings

Fittings shall conform to AASHTO M294 or AASHTO MP7. Fabricated fittings shall be welded at all accessible interior and exterior junctions.

### Material Properties

Pipe and fitting material shall be high-density polyethylene meeting ASTM D3350 minimum cell classification 335400C. The pipe material shall be Hancor Resin 8™, which is a slow crack resistant material evaluated using the single point notched constant tensile load (SP-NCTL) test. Average SP-NCTL test specimens must exceed 24 hrs. with no test result less than 17 hrs. The closed cell structural foam core must have a free rise density no less than 3 lbs/ft<sup>3</sup> and compressive strength no less than 20 lbs/in<sup>2</sup>.

### Quality Assurance

All corrugated polyethylene pipe meeting or exceeding AASTHO M294 or MP7 shall only be provided by manufactures listed by the Plastics Pipe Institute (PPI) as having met the requirements of the PPI sponsored third-party certification program. All AASHTO M294 and MP7 pipe shall be clearly marked with a certification program mark or logo representing the supplied pipe is in compliance with all applicable standards.

### Installation

Installation shall be in accordance with ASTM D2321, with the exception that minimum cover in trafficked areas for 12- through 48-inch (300 to 1200 mm) diameters shall be 1 ft. (0.3 m) and for 60-inch (1500 mm) diameter, the minimum cover shall be 1.5 ft. (0.5 m).

# 1-0 SPECIFICATIONS

## TABLE OF CONTENTS

Hancor Blue Seal™ Pipe Specifications .....	1-2
Hancor Sure-Lok® WT Pipe Specifications .....	1-4
Hancor Sure-Lok® F477 Pipe Specifications .....	1-6
Hancor EcoFirst™ Pipe Specifications.....	1-8
Hancor Hi-Q® Pipe Specifications .....	1-10
Hancor AASHTO Pipe Specifications .....	1-11
Hancor Heavy Duty Pipe Specifications .....	1-12
Hancor Smoothwall Sewer & Drain Pipe Specifications .....	1-13
Hancor Channel-Flow® Pipe Specification .....	1-14
Hancor Channel-Muck Pipe Specification .....	1-15
Hancor Gravelless Pipe Specification.....	1-16
Hancor Drain Grate Specification .....	1-17
Hancor Hi-Q Flared End Section Specification.....	1-18
Hancor Meter Pit Specification.....	1-19
Hancor EnviroChamber™ Specification .....	1-20
Hancor Heavy Duty Distribution Box Specification.....	1-21
Hancor Multi-Purpose Distribution Sump Specification.....	1-22
Hancor Standard Alternator Valve Specification .....	1-23
Hancor Radon Dual Purpose Vented Sump Specification.....	1-24
Hancor Sewage Ejector Sump Specification .....	1-25
Hancor Sump Pump Well Specification .....	1-26
Hancor Water Control Gate Specification.....	1-27
Hancor Hi-Q Sloped End Section Specification.....	1-30

*All sales of Hancor product are subject to a limited warranty and purchasers are solely responsible for installation and use of Hancor products and determining whether a product is suited for any specific needs. Please consult a full copy of Hancor's Terms and Conditions for Sale for further details.*

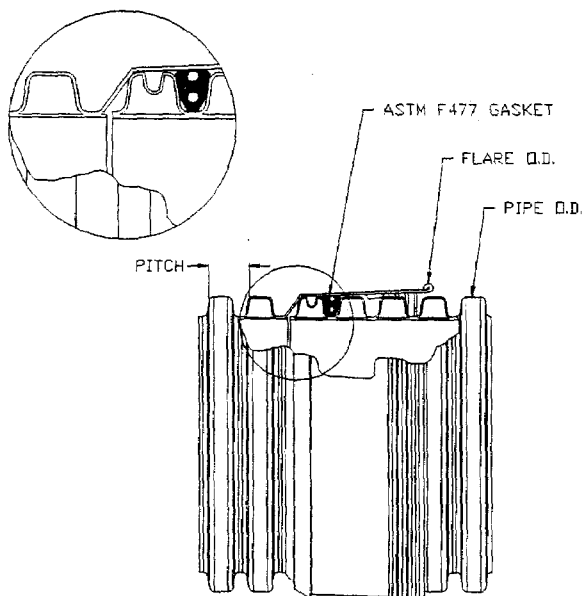


## BLUE SEAL™ JOINT SYSTEM

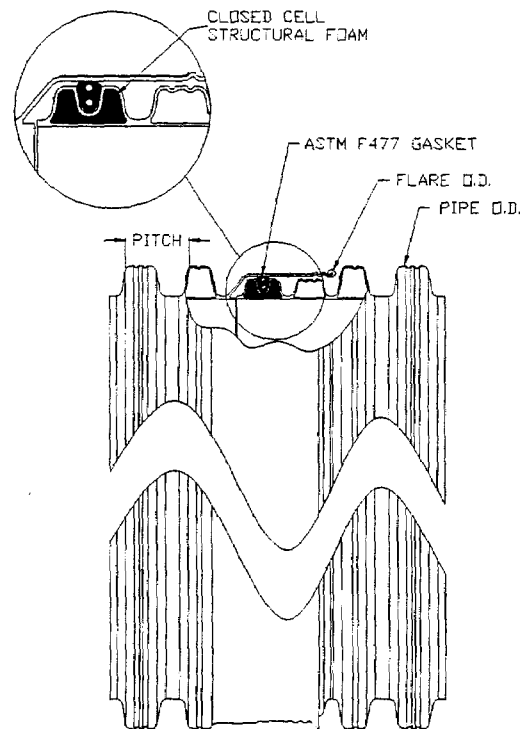
(Joint configuration & availability subject to change without notice.)

### Pipe Dimensions

		Nominal Diameter, in (mm)								
Pipe (mm)	in I.D.	12 (300)	15 (375)	18 (450)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	60 (1500)
Pipe O.D.	in (mm)	14.2 (361)	17.7 (450)	21.5 (546)	28.4 (721)	36.0 (914)	41.4 (1052)	48.0 (1219)	55.0 (1397)	67.3 (1709)
Flare O.D.	in (mm)	15.4 (391)	19.6 (498)	23.9 (607)	29.9 (759)	37.9 (963)	43.6 (1107)	50.8 (1290)	57.4 (1458)	73.7 (1872)
Pitch (mm)	in	2.0 (51)	2.4 (61)	3.0 (76)	4.0 (102)	4.0 (102)	4.6 (117)	5.8 (147)	5.8 (147)	7.8 (198)
stick	Lb/20 ft.	70	100	130	220	330	400	500	597	861
Approx. Weight (stick)	(Kg/6m)	(32)	(46)	(59)	(100)	(150)	(182)	(227)	(260)	(315)



12'-18' (300-450mm)



24'-60' (600-1500mm)

## HANCOR SURE-LOK® WT PIPE SPECIFICATIONS

### Scope

This specification describes 4- through 8-inch (100 to 200 mm) Hancor Sure-Lok WT pipe for use in non-pressure drainage applications.

### Pipe Requirements

Sure-Lok WT pipe shall have a smooth interior and annular exterior corrugations.

- 4- to 8-inch (100 to 200 mm) shall meet AASHTO M252, Type S.
- Manning's "n" value for use in design shall not be less than 0.010.

### Joint Performance

Pipe shall be joined with the Sure-Lok joint meeting the requirements of AASHTO M252. The joint shall be watertight according to the laboratory requirements of ASTM D3212. Joints shall remain watertight when subjected to a 1.5 degree axial misalignment.

Gaskets shall be made of polyisoprene meeting the requirements of ASTM F477 with the addition that the gaskets shall not have any visible cracking when tested according to ASTM D1149 after 72 hour exposure in 50 PPHM ozone at 104° F (40° C).

Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. A joint lubricant supplied by the manufacturer shall be used on the gasket and bell during assembly.

### Fittings

4" – 8" (100 – 200 mm) fittings shall conform to AASHTO M252.

### Material Properties

Pipe and fitting material shall be high density polyethylene meeting ASTM D3350 minimum cell classification 324420C for 4- through 8-inch (100 to 200 mm) diameters.

### Installation

Installation shall be in accordance with ASTM D2321 with the exception that minimum cover in trafficked areas shall be one-foot (0.3 m).

### Pipe Dimensions

Nominal Pipe I.D.	in	4	6	8
(mm)		(100)	(150)	(200)
Approx. Pipe O.D.	in	4.7	6.9	9.4
(mm)		(119)	(175)	(239)
Approx. Pitch	in	0.6	0.7	1.0
(mm)		(16)	(19)	(26)
Approx. Weight*	Lb/20 ft	10	20	30
stick	(kg/6m)	(5)	(9)	(14)
stick)				
Perforations	All diameters available with or without perforations			

\*One stick is 20' (6m) for 4" – 8" (100 – 200 mm) diameter pipe.

\*Check with sales representative for availability.



THE MOST  
RELIABLE  
NAME IN  
DRAINAGE  
SYSTEMS



MARKETS WE SERVE

PRODUCTS

TECHNICAL SUPPORT

CUSTOMER SERVICE

#### CONTACT ADS



Phone, Fax or E-mail us with product questions or comments about our website.

#### SALES INFORMATION



Get ADS Sales/Pricing Information

#### LANGUAGE / IDIOMA



[Cambie al español](#)

#### RELATED INFORMATION



See related Pipe Technical Data



View Products by Market



View Products by Product Type



Product-related questions? See our Product/Technical FAQs

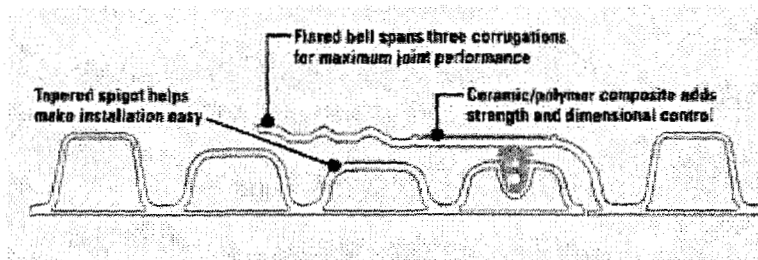
## N-12 IB WT (water-tight) Pipe



N-12 IB WT's ceramic/polymer composite joint c HDPE's excellent abrasion and corrosion resistance joint with excellent strength. The wide proprietary ceramic/polymer composite is fused to the outside built-in bell, improving the joint's integrity and tol

With its integral built-in bell and factory-installed gasket, the pipe requires no extra or other sealants to install. The joint meets or exceeds ASTM 3212 lab test and ASTM field test, which helps fill an essential role in meeting the new, stricter Environmental Agency guidelines.

N-12 IB WT pipe is so advanced in its design, it's easy to install and easy to put you for long term reliability.



#### Applications:

[Storm Sewers](#)  
[Sanitary Sewers](#)  
[Retention/Detention](#)  
[Roof Drainage](#)

#### N-12 IB WT

Includes a pressure-tested coupler that provides watertight connections meeting a full accordance with ASTM D3212.

ProLink WT PipeProduct Information	
Diameters Available:	4"-60"
Lengths Available:	3m
Joint Performance:	Water-tight(D3212)
Joining System:	Integral Bell
Specifications:	<a href="#">Product Note 3.107</a>

# Product Notes

## Product Note 3.107

**Re:** Specification for Smooth Interior  
Corrugated Polyethylene Pipe

**Date:** June 17, 2002



This specification applies to high density polyethylene corrugated pipe with an integrally formed smooth waterway. Nominal sizes for which this specification is acceptable are 100 – 1500 mm (4 - 60 inch) diameters. Sizes 100 – 1500 mm (4 - 60 inch) shall be either AASHTO Type 'S' or Type 'D' as follows. Sizes 100 – 1500 mm (4 - 60 inch) designated as AASHTO Type 'S' (N-12) shall have a full circular cross-section, with an outer corrugated pipe wall and an essentially smooth inner wall (waterway). Corrugations for Type 'S' sizes 100 – 1500 mm (4 - 60 inch) shall be annular (N-12). Sizes 1050 – 1500 mm (42 thru 60 inch) designated as AASHTO Type 'D' (N-12HC) shall consist of an essentially smooth waterway braced circumferentially with circular ribs which are formed simultaneously with an essentially smooth outer wall. The 1050 – 1500 mm (42 thru 60 inch) (N-12HC) sizes shall conform to AASHTO Type 'D' (which describes dual wall pipe with a smooth waterway).

Pipe manufactured for this specification shall comply with the requirements for test methods, dimensions and markings found in AASHTO Designations M252, M294 and MP7. Pipe and fittings shall be made from virgin PE compounds which conform with the applicable current edition of the AASHTO Material Specifications for cell classification as defined and described in ASTM D3350.

The minimum parallel plate stiffness values when tested in accordance with ASTM D2412 shall be as follows:

Diameter (nominal)	Pipe Stiffness (minimum)	Diameter (nominal)	Pipe Stiffness (minimum)
100 mm (4")	340 kN/m <sup>2</sup> (50 pii)	600 mm (24")	235 kN/m <sup>2</sup> (34 pii)
150 mm (6")	340 kN/m <sup>2</sup> (50 pii)	750 mm (30")	195 kN/m <sup>2</sup> (28 pii)
200 mm (8")	340 kN/m <sup>2</sup> (50 pii)	900 mm (36")	150 kN/m <sup>2</sup> (22 pii)
250 mm (10")	340 kN/m <sup>2</sup> (50 pii)	1050 mm (42")	140 kN/m <sup>2</sup> (20 pii)
300 mm (12")	345 kN/m <sup>2</sup> (50 pii)	1200 mm (48")	125 kN/m <sup>2</sup> (18 pii)
375 mm (15")	290 kN/m <sup>2</sup> (42 pii)	1500 mm (60")	95 kN/m <sup>2</sup> (14 pii)
450 mm (18")	275 kN/m <sup>2</sup> (40 pii)		

The fittings shall not reduce or impair the overall integrity or function of the pipeline. Fittings may be either molded or fabricated. Common corrugated fittings include in-line joint fittings, such as couplers and reducers, and branch or complimentary assembly fittings such as tees, wyes and end caps. These fittings may be installed by various methods such as snap-on, bell and spigot, bell – bell and wrap around couplers. Couplers shall provide sufficient longitudinal strength to preserve pipe alignment and prevent separation at the joints. Only fittings supplied or recommended by the manufacturer shall be used. Where designated on the plans or project specifications, an elastomeric gasket meeting the requirements of ASTM F477 shall be supplied.

Installation of the pipe specified above shall be in accordance with either AASHTO Section 30 or ASTM Recommended Practice D2321 as described elsewhere in these specifications and as recommended by the manufacturer.